SKY CARBON CLEANUP AND BIODIVERSITY RESTORATION: DEVISING REGIONAL FRAMEWORKS

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INTRODUCTION

"In this planetary climate emergency, the level of our ambition must match the scale of the threat."[2]

Our planet faces a climate emergency, and the next few years encompass a critical, final window of opportunity to stave off tipping points. In addition to full and rapid decarbonization of the energy system, global society must draw down and sequester the excess legacy atmospheric carbon that is heating the planet to dangerous levels.[3] In essence, society must accomplish a massive sky cleanup. This project must start with land-based, natural climate solutions (NCS), which are protocols of land management that boost Nature's own capacity for storing carbon. Such measures are necessary both to regain climate stability and to recover Earth's biodiversity and ecological systems that remain vital to Humanity's survival.[4] As this crisis intensifies, nothing short of a meta-strategy is needed to jumpstart a planetary project of ecological restoration and regeneration, which requires reconstructing the human relationship with the natural world.

This Article proposes Regional Frameworks for organizing the global drawdown project. Such Frameworks are non-governmental, opportunity-announcing informational platforms that can guide carbon sequestration across a region with the aim of maximizing co-benefits of ecosystem recovery, climate resilience, and rural economic revival. Frameworks can create an implementation bridge between NCS opportunity and practice across broad landscapes. Part I of this Article explains the need for atmospheric carbon drawdown as well as the necessity for biodiversity protection. It broadly describes categories of natural climate solutions arranged by four ecotypes: (1) forests; (2) farmlands; (3) grasslands and rangelands; and (4) blue carbon and teal carbon areas. Part II introduces a meta-strategy for catalyzing drawdown in regions worldwide. This strategy is comprised of a "three-gear" approach: (1) developing Regional Atmospheric Recovery Frameworks; (2) financing such Frameworks; and (3) instituting Regional Sky Trusts to carry out the drawdown projects. The discussion differentiates this approach from the more well-known efforts

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2. MARY CHRISTINA WOOD, PROSPECTUS FOR PACIFIC NORTHWEST FRAMEWORK FOR ATMOSPHERIC RECOVERY 1 (2022) [hereinafter PROSPECTUS].

3. *See* UN Intergovernmental Panel on Climate Change, Climate Change 2023 Synthesis Report: Summary for Policymakers 19 (2023), https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf ("Carbon dioxide removal [(drawdown)] will be necessary to achieve net negative CO_2 emissions.").

4. *See id.* at 21 ("[B]iological [carbon drawdown] methods like reforestation, improved forest management, soil carbon sequestration, peatland restoration and coastal blue carbon management can enhance biodiversity and ecosystem functions, employment and local livelihoods."); *see also infra* notes 18–26.

focused on carbon offsets, which this Article argues are fundamentally misguided and undermine climate recovery. Part III then focuses on the Framework as the first, most basic "gear" in this strategy, explaining it as an organizing nucleus around which regional efforts can coalesce. It discusses the purpose of a Framework, underscores the need to incorporate Native perspectives and leaders at every stage in the process, and inventories the components of the Framework. Part IV describes a Regional Framework process already underway in the Pacific Northwest (PNW). The PNW is uniquely positioned to lead the NCS challenge due to its high sequestration potential (with a geographic base containing all four ecotypes) and the plethora of people and entities in the region already researching, developing, and implementing NCS techniques across the land. In particular, the leadership of Native nations in restoring ecology across the PNW contributes distinctive vision and Indigenous knowledge to the regional enterprise. Part V proposes Regional Atmospheric Recovery Institutes to sustain the effort of deploying NCS through the end of the century in a globally interactive and organized way.

I. THE IMPERATIVE AND POTENTIAL FOR HARNESSING NATURAL CLIMATE SOLUTIONS

No corner of Earth remains untouched from climate disruption. It now pummels the planet with floods, fires, droughts, mega-storms, heat waves, and sea-level rise. Scientists warn that continuing to emit greenhouse gases (GHGs) while failing to draw down excess carbon dioxide (CO_2) that has already accumulated in the atmosphere will cause large parts of our planet to become uninhabitable.[5] This widely recognized "direct existential threat,"[6]

5. *See generally* DAVID WALLACE-WELLS, THE UNINHABITABLE EARTH: LIFE AFTER WARMING (2019); David Wallace-Wells, *Jared Diamond: There's a 49% Chance the World as We Know it Will End by 2050*, N.Y. MAG. (May 10, 2019), https://nymag.com/intelligencer/2019/05/jared-diamond-on-his-new-book-upheaval.html (discussing Jared Diamond's new book, *Upheaval*); Jonathan Watts, *Human Society Under Urgent Threat from Loss of Earth's Natural Life*, GUARDIAN (Oct. 29, 2021), https://www.theguardian.com/environment/2019/may/06/human-society-under-urgent-threat-loss-earth-natural-life-un-report (summarizing the Intergovernmental Panel on Climate Change's (IPCC) 2019 Assessment Report); *World Is "On Notice" as Major UN Report Shows One Million Species Face Extinction*, UN NEWS (May 6, 2019), https://new.un.org/en/story/2019/05/1037941.

6. *See, e.g.*, Brian Pascus, *Human Civilization Faces "Existential Risk" by 2050 According to New Australian Climate Change Report*, CBS NEWS (June 4, 2019), https://www.cbsnews.com/news/new-climate-change-report-human-civilization-at-risk-extinction-by-2050-new-australian-climate ("'[C]limate change now represents a near- to mid-term existential threat' to human civilization."); *see also* April Siese, *We Need to Ditch Coal Before It's Too Late, Climate Activist Bill McKibben Warns*, CBS NEWS (May 13, 2019), https://www.cbsnews.com/news/environmentalist-bill-mckibben-says-skipping-coal-and-natural-gas-key-to-combating-climate-change-cbsn-originals/?intcid=CNM-00-10abd1h (offering an explanation by Bill McKibben, author of *Falter*, on the risk of human extinction from climate change); Edith M. Lederer,

worsening for decades, now approaches proximate climate tipping points poised to trigger runaway climate change beyond our control.[7] Some of these dangerous feedbacks are already in motion, like rising temperatures causing melting permafrost, which in turn releases CO_2 and methane that further drive up global temperatures.[8] In a recent study, scientists' models predict that "highly populated regions of the world will be rendered uninhabitable sooner than previously thought for parts of each year."[9]

This climate emergency requires an urgent global response, and time is running out.[10] The coming few years are critical.[11] Stabilizing the planet's climate system requires returning the atmospheric CO_2 to below 350 parts per million (ppm), deemed the highest safe level.[12] Present levels are climbing past 420 ppm (annual global average), whereas pre-Industrial levels were about 280 ppm.[13] This excess "legacy carbon" in the atmosphere came from emissions associated with 150 years of fossil-fueled industrial activity

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UN Chief: World Must Prevent Runaway Climate Change by 2020, AP (Sept. 10, 2018), https://apnews.com/article/floods-united-nations-antonio-guterres-us-news-climate-71ab1abf44c14605bf2dda29d6b5ebcc (quoting UN Chief stating that world faces a "direct existential threat" and must begin the shift away from fossil fuels by 2020 to prevent "runaway climate change").

7. *See* Stockholm Resilience Center, *Earth at Risk of Heading Towards "Hothouse Earth" State*, SCI. DAILY (Aug. 6, 2018), https://www.sciencedaily.com/releases/2018/08/180806152040 (quoting the co-author of a study published in the Proceedings of the National Academy of Sciences: "These tipping elements can potentially act like a row of dominoes. Once one is pushed over, it pushes Earth towards another. It may be very difficult or impossible to stop the whole row of dominoes from tumbling over. Places on Earth will become uninhabitable if 'Hothouse Earth' becomes the reality."); *Secretary-General's Remarks on Climate Change [as Delivered]*, UN (Sept. 10, 2018), https://www.un.org/sg/en/content/sg/statement/2018-09-10/secretary-generals-remarks-climate-change-delivered ("We are careening towards the edge of the abyss.").

8. *See* Yale Forum for Climate Change and the Media, *Permafrost: The Climate's Tipping Time Bomb* (Greenman Studio), *https://worldbusiness.org/permafrost-the-climates-tipping-time-bomb/* (last visited Mar. 18, 2024).

9. Andrew Freedman & Jason Samenow, *Humidity and Heat Extremes Are on the Verge of Exceeding Limits of Human Survivability, Study Finds*, WASH. POST (May 8, 2020), https://www.washingtonpost.com/weather/2020/05/08/hot-humid-extremes-unsurvivable-global-warming/.

10. Andrew Freedman, *More than 11,000 Scientists from Around the World Declare a 'Climate Emergency'*, WASH. POST (Nov. 5, 2019), https://www.washingtonpost.com/science/2019/11/05/more-than-scientists-around-world-declare-climate-emergency/.

11. *Id.*; *see also* Beverly Law et al., *Creating Strategic Reserves to Protect Forest Carbon and Reduce Biodiversity Losses in the United States*, 11 LAND 721 (2022) [hereinafter Law et al., *Creating Strategic Reserves*].

12. *See* Nicola Jones, *How the World Passed a Carbon Threshold and Why It Matters*, YALE ENV'T 360 (Jan. 26, 2017), https://e360.yale.edu/features/how-the-world-passed-a-carbon-threshold-400ppm-and-why-it-matters (quoting climate scientist Dr. James Hansen: "If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted . . . CO2 will need to be reduced . . . to at most 350 ppm[.]").

13. *A New 66 Million-year History of Carbon Dioxide Offers Little Comfort for Today*, COLUM. CLIMATE SCH. (Dec. 7, 2023), https://phys.org/news/2023-12-million-year-history-carbon-dioxide-comfort.html.

and deforestation, most of it from the last half-century.[14] This has caused a global mean temperature rise of 1.1℃, which has in turn triggered climate disruption and natural disasters worldwide.[15]

Scientists emphasize that restoring climate balance requires a two-prong approach. The first prong requires rapid decarbonization—at least 50% emissions reduction by 2030 and a complete transition away from carbon-intensive fossil fuels by at least mid-century.[16] But as ambitious as that is, decarbonization alone is not sufficient. The second prong necessitates the drawdown and sequestration of 150 or greater gigatons of carbon (GtC) by 2100—in essence, a massive sky carbon cleanup.[17]

While the climate crisis moves rapidly towards points of no return, it collides with another planetary emergency: the collapse of biodiversity. Species are dying out at 1,000 to 10,000 times the rate they would have without human intervention.[18] According to one estimate, as much as half of all currently living species could go extinct by the end of 2050.[19] This new

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14. *Global Temperatures*, NASA EARTH OBSERVATORY, https://earthobservatory.nasa.gov/world-of-change/global-temperatureschange/global-temperatures (last visited Sept. 23, 2022); Katherine Hignett, *Here's How Much Carbon Dioxide Emissions Have Increased Since the Industrial Age*, NEWSWEEK (May 1, 2018), https://www.newsweek.com/carbon-dioxide-climate-change-fossil-fuels-906953.

15. *See WMO Update: 50:50 Chance of Global Temperature Temporarily Reaching 1.5℃ Threshold in Next Five Years*, WORLD METEOROLOGICAL ORG. (May 9, 2022), https://wmo.int/news/media-centre/wmo-update-5050-chance-of-global-temperature-temporarily-reaching-15degc-threshold-next-five-years (explaining that recently, the World Meteorological Organization determined there is a 50% chance the annual average global temperature will reach 1.5℃ above pre-industrial levels in at least one of the years between 2022 and 2026).

16. *IPCC Report: The Evidence Is Clear: The Time for Action Is Now. We Can Halve Emissions by 2030.*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Apr. 4, 2022), https://www.ipcc.ch/2022/04/04/ipcc-ar6-wgiii-pressrelease/.

17. *See* James Hansen et al., *Young People's Burden: Requirement of Negative CO_2 Emissions*, 8 EARTH SYS. DYNAMICS 577, 595 (2017), https://esd.copernicus.org/articles/8/577/2017/esd-8-577-2017.pdf ("There is no time to delay.") (estimating required drawdown of 150 GtC equivalent, according to updated scenarios, and noting that the amount of necessary drawdown increased—from 100 GtC equivalent estimated in 2013 to 150 GtC equivalent estimated in 2017—due to delay in starting emissions reduction; also explaining that the amount of carbon in the atmosphere now exceeds the capability of natural drawdown, but noting that "at least a large fraction of required CO2 extraction can be achieved via relatively natural agricultural and forestry practices with other benefits"). Some estimate the necessary cleanup to be up to 1000 GtC by 2100, depending on society's emissions reduction accomplishments or failures. *See* G. Philip Robertson et al., *Land-Based Climate Solutions for the United States*, 28 GLOB. CHANGE BIOLOGY 4912, 4913 (May 31, 2022), https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcb.16267 (tied to goal of limiting temperature rise to 1.5°C); UN Intergovernmental Panel on Climate Change, Special Report: Global Warming of 1.5°C, Summary for Policymakers 17 (Oct. 8, 2018), https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/.

18. Renee Cho, *Why Endangered Species Matter*, COLUM. CLIMATE SCH. (Mar. 26, 2019), https://news.climate.columbia.edu/2019/03/26/endangered-species-matter/.

19. *See* Chris D. Thomas et al., *Extinction Risk from Climate Change*, NATURE (Jan. 8, 2004), https://www.nature.com/articles/nature02121; *see also* Gerardo Ceballos et al., *Biological Annihilation via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines*, 114

mass extinction event, driven by human actions, has been labeled the "Sixth Extinction."[20] This existential threat to biodiversity threatens Humanity's health, food supply, and security.[21] These threats also exacerbate long-standing social and environmental injustices.[22]

Leading scientists emphasize that the climate and biodiversity crises must be addressed in an integrated fashion, not separately, or solutions to one may exacerbate the other.[23] A sky-cleanup strategy deploys a set of measures known as "natural climate solutions" (NCS), which hold impressive potential to absorb CO_2 and sequester it in plants and soils.[24] One team of researchers estimates the sequestration potential of land-based NCS across the U.S. alone to be the equivalent of 21% of the nation's current net annual emissions.[25] The goal is to enlarge and protect the natural carbon "sinks" of the world in a way that supports biodiversity and human needs. Leading research points to practices that promote soil- or plant-based carbon sequestration across four ecotypes: (1) forests; (2) farmlands; (3) rangelands and grasslands; and (4) blue and teal carbon (wetlands) areas.[26] These projects would engage

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PNAS 90 (2017), https://www.pnas.org/doi/10.1073/pnas.1704949114. Already, "[r]oughly a third (8,851/27,600) of all land vertebrate species examined are experiencing declines and local population losses of a considerable magnitude," and of the mammal species sampled in one study, almost half had lost more than 80% of their ranges since 1900. *Id.* Additionally, "[a]s much as "50% of the number of animal individuals that once shared Earth with us are already gone[.]" *Id.*

20. *See* ELIZABETH KOLBERT, THE SIXTH EXTINCTION: AN UNNATURAL HISTORY (2015).

21. Catrin Einhorn, *A 'Crossroads' for Humanity: Earth's Biodiversity Is Still Collapsing*, N.Y. TIMES, https://www.nytimes.com/2020/09/15/climate/biodiversity-united-nations-report.html, (Oct. 14, 2021).

22. *See generally* Robert Watson, *Biodiversity Touches Every Aspect of Our Lives – So Why Has Its Loss Been Ignored?*, GUARDIAN (Sept. 19, 2019), https://www.theguardian.com/environment/2019/sep/19/biodiversity-touches-every-aspect-of-our-lives-so-why-has-its-loss-been-ignored ("[L]oss of biodiversity hurts the poorest people, further exacerbating an already inequitable world."); S. Nazrul Islam & John Winkel, *Climate Change and Social Inequality* 4 (UN Dep't of Econ. & Soc. Affs., Working Paper No. 152, 2017), https://www.un.org/esa/desa/papers/2017/wp152_2017.pdf.

23. *See* Catrin Einhorn, *Our Response to Climate Change Is Missing Something Big, Scientists Say*, N.Y. TIMES, https://www.nytimes.com/2021/06/10/climate/biodiversity-collapse-climate-change.html (Oct. 7, 2021) (citing to scientific authority to support the assertion of an integrated approach to climate change and biodiversity loss); *see also* Law et al., *Creating Strategic Reserves*, *supra* note 11 (emphasizing the need for integrated approaches to climate change mitigation and biodiversity restoration); Thomas Crowther, *We Can't Address the Climate Crisis Without Nature*, TIME (Nov. 29, 2023), https://time.com/6340530/climate-change-nature/ ("[Mo]noculture 'carbon farms' are not the restoration of nature. In fact, they are often the destruction of it.").

24. Bronson W. Griscom et al., *Natural Climate Solutions*, 114 PNAS 11645, 11647 (2017).

25. Joseph E. Fargione et al., *Natural Climate Solutions for the United States*, SCI. ADVANCES, Nov. 4, 2018, at 1, 1 (2018); *see also* Robertson et al., *supra* note 17, at 4914 (noting that another, more recent analysis estimates a potential mitigation amount in the U.S. at 110 GtC equivalent if natural climate solutions are combined with bioenergy solutions that would replace some fossil-fuel streams for transportation and other needs; such an estimate combines sequestration with decarbonization gains).

26. *See generally id.*; *see also* Calvin Norman, *How Forests Store Carbon*, PENN STATE EXTENSION (Aug. 22, 2023), https://extension.psu.edu/how-forests-store-carbon (indicating general discussion of the practices that promote soil- or plant-based carbon sequestration); Todd A. Ontl & Lisa

foresters, farmers, ranchers, and land managers to harness Nature's own engines of carbon sequestration, as described in more detail below. But invoked without concern for biodiversity, they may work at cross-purposes for species recovery.[27] The discussion below first describes the global potential of NCS and then briefly inventories the four ecotypes that are amenable to NCS. It omits the potential of ocean-based blue-carbon initiatives as beyond the scope of this Article.[28]

A. The Global Capacity for Natural Climate Solutions

Earth maintained a relatively stable climate throughout Humanity's existence until the start of the Industrial Revolution, when burgeoning industry drew forth carbon fuels stored in below-ground deposits and combusted them, emitting vast quantities of CO_2 into the atmosphere and disrupting the carbon cycle.[29] The excess legacy carbon in the atmosphere—the amount of carbon that needs to be cleaned up in order to return to safe concentrations and thereby regain climate stability—totals at least 150 GtC, perhaps even much more.[30] That amount of legacy carbon grows with every day of continuing fossil-fuel emissions across the planet.

In 2017, a seminal scientific paper announced the potential to remove vast amounts of CO_2 through NCS.[31] NCS harnesses Nature's own processes to draw down atmospheric carbon and sequester it through improved land management and conservation techniques. In 2013, Dr. James Hansen, then head of NASA's Goddard Institute for Space Studies, led a team of scientists to produce a paper that estimated that NCS could, if deployed and scaled to

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A. Schulte, *Soil Carbon Storage*, NATURE EDUC. KNOWLEDGE (2012), https://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790/; Kat Kerlin, *Grasslands More Reliable Carbon Sink than Trees*, U.C. DAVIS (July 9, 2018), https://climatechange.ucdavis.edu/climate/news/grasslands-more-reliable-carbon-sink-than-trees; *see also* A.M. Nahlik & M.S. Fennessy, *Carbon Storage in U.S. Wetlands*, NATURE COMM'CNS, Dec. 13, 2016, at 1, https://www.nature.com/articles/ncomms13835.

27. For example, natural climate solutions such as planting trees in grasslands may absorb carbon but may also threaten localized species reliant on that habitat.

28. *See, e.g.*, *How Whales Help Cool the Earth*, BBC (Jan. 20, 2021), https://www.bbc.com/future/article/20210119-why-saving-whales-can-help-fight-climate-change (discussing the potential of ocean carbon-sequestration processes involving marine species).

29. *Carbon Dioxide Now More than 50% Higher than Pre-Industrial Levels*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. (June 3, 2022), https://www.noaa.gov/news-release/carbon-dioxide-now-more-than-50-higher-than-pre-industrial-levels ("Prior to the Industrial Revolution, CO_2 levels were consistently around 280 ppm for almost 6,000 years of human civilization. Since then, humans have generated an estimated 1.5 trillion tons of CO_2, much of which will continue to warm the atmosphere for thousands of years.").

30. *See* discussion *supra* note 17.

31. Griscom et al., *supra* note 24, at 11645–50; *see also* Fargione et al., *supra* note 25 (referencing the Griscom Paper).

maximize opportunity worldwide, draw down 100 GtC by 2100.[32] More recent leading analysis reaffirms that potential.[33] In all likelihood, technological approaches are required to remove the remaining 50 GtC when Nature's processes have been exhausted.

The focus on technological solutions coalesces around direct air capture (DAC) of carbon, which uses equipment to pull carbon from the atmosphere and store it underground.[34] While DAC may hold promise for the future, it faces immediate financial and technological impediments.[35] Other extreme and risky interventions exist, such as fertilizing the ocean with massive amounts of iron in an aim to spur growth of plankton and other plants that will absorb carbon.[36] Among the array of options, NCS techniques are the most well-studied, cost-effective, mature, and presently scalable drawdown solutions.[37] Properly designed, NCS techniques hold significant advantages over technical solutions or chemical interventions. NCS may respond to the other crisis of biodiversity and can provide crucial co-benefits of food production, water protection, and climate adaptation.[38] Because NCS involves land management on a localized level, these solutions may engage and empower local communities rather than consolidate power and decision-making in a small number of corporations—concerns that have been raised with respect to geo-engineering and technology-based interventions.

The drawdown potential of NCS is a function of how much the carbon-sequestering capacity of land- and water-based systems is actualized through human management of those systems. NCS consists of ecosystems and

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32. James Hansen et al., *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, PLOS ONE, Dec. 3, 2013, at 1, 10, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3849278/; *see also* Griscom, *supra* note 24, at 11645 (applying constraints allowing for biodiversity protection and human needs for food and fiber and estimating that NCSs could draw down a maximum of 23.8 Gt CO_2e by 2030).

33. *See* Robertson et al., *supra* note 17, at 4913 (assessing U.S. potential); *see also* Fargione et al., *supra* note 25 (investigating the combination of bioenergy fuels and carbon sequestration).

34. *DOE Explains Direct Air Capture*, OFF. OF SCI., DEP'T OF ENERGY, https://www.energy.gov/science/doe-explainsdirect-air-capture (last visited Feb. 12, 2024).

35. EUR. ACAD. SCI. ADVISORY COUNCIL, NEGATIVE EMISSION TECHNOLOGIES: WHAT ROLE IN MEETING PARIS AGREEMENT TARGETS? 8, 30 (2018), http://unfccc.int/sites/default/files/resource/28_EASAC%20Report%20on%20Negative%20Emission%20Technologies.pdf (discussing barriers to carbon storage associated with DAC and other strategies) ("Installing the capacity required to capture and store the quantities of CO2 envisaged comprises a huge engineering challenge, so inevitably will have the long planning times associated with other major societal infrastructure projects."); *see also* Griscom et al., *supra* note 24, at 11647 (comparing costs and drawbacks of NCS versus technology-based carbon capture and storage).

36. EUR. ACADS. SCI. ADVISORY COUNCIL, *supra* note 35, at 9–10 (describing ocean fertilization and carbon capture and storage).

37. *See* Renee Cho, *Natural Climate Solutions: Why We Need Them*, COLUM. CLIMATE SCH.: STATE OF THE PLANET (Sept. 23, 2021), https://news.climate.columbia.edu/2021/09/23/natural-climate-solutions-why-we-need-them/.

38. Griscom et al., *supra* note 24, at 11646 (including food, fiber, and biodiversity safeguards in estimates of NCS).

agricultural systems essentially mining CO_2 from the atmosphere as a result of plant photosynthesis. Flora, fauna, microbiota, and soils assimilate carbon.[39] Because the rate and scale of drawdown from NCS is determined through photosynthesis and other ecological processes, NCS techniques sequester carbon slowly compared to the rate of emissions from fossil-fuel combustion.[40] The climate-stabilization benefits of NCS will take many decades to accrue. Moreover, the land base required for NCS techniques to measurably help steer the Earth system back towards 350 ppm of atmospheric CO_2 is vast; consequently, the project must incorporate land across the globe.[41] Implementation of NCS techniques at the necessary scale requires rapid development of sophisticated and responsive institutions.

The enormous land base needed for NCS to successfully play a role in atmospheric cleanup runs up against the sheer extent of human impact on land-based systems. Much of Earth's land is degraded and acts as a net source of atmospheric carbon, necessitating an urgent shift toward "regenerating the planet" through preservation, restoration, and improved land use.[42] At the same time, NCS measures must support human communities, as discussed in Part III. To set the context, the following Section explores the four ecotypes that serve as Nature's natural engines of carbon sequestration and biodiversity support.

B. The NCS Ecotypes

Land-based NCS focuses on these primary ecotypes: (1) forests; (2) farmlands; (3) grasslands and rangelands; and (4) blue carbon and teal carbon (wetlands) areas.[43] Of these, regions will vary as to which ecotypes offer the most potential, depending on the biological and geological characteristics of the land base and the land uses on that base.[44] In the PNW region, for example, forests likely offer the greatest drawdown potential due to the immense carbon-absorbing capacity of Douglas fir trees, but that could change over time as forests perish from fire.[45] Across regions, soil carbon is

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39. *DOE Explains Carbon Sequestration*, OFF. OF SCI., DEPT. OF ENERGY, https://www.energy.gov/science/doe-explainscarbon-sequestration (last visited Mar. 20, 2024) (explaining biological sequestration in plants and soils).

40. Dennis Baldocchi & Josep Penuelas, *The Physics and Ecology of Mining Carbon Dioxide from the Atmosphere by Ecosystems*, 25 GLOB. CHANGE BIOLOGY 1191, 1195 (2019).

41. *See* Hansen et al., *supra* note 32 (supporting the assertion that a large amount of land globally will be required for NCS to work at the scale needed); *see also* Griscom et al., *supra* note 24 (same).

42. Griscom et al., *supra* note 24, at 11649.

43. *See id.* at 11645–46 (explaining that although oceans hold the largest carbon pool on Earth, they are not susceptible to the same management and are generally excluded from NCS's literature).

44. *See* Bronson W. Griscom, et al., *National Mitigation Potential from Natural Climate Solutions in the Tropics*, ROYAL SOC'Y, Jan. 27, 2020, at 1, 6.

45. Law et al., *Creating Strategic Reserves*, *supra* note 11, at 2.

generally a key focus in all four ecotypes and constitutes 25% of the overall drawdown potential of NCS.[46] Of that overall potential, 40% is achievable through preserving existing soil carbon, and the remaining 60% is achievable through restoration of depleted soil.[47] Within each of the four categories, some scientists segregate measures into three types of endeavor: (1) avoided-conversion NCS (i.e., preventing forests from being converted to development or grasslands from being converted to croplands, as both measures reduce the soil's ability to store carbon); (2) land-management NCS (such as planting cover crops on fields or establishing longer forest-harvest rotations); and (3) restoration NCS (such as reforesting an area that has been cut or removing a dike to re-water a former estuary).[48] Accelerated silicate weathering is an emerging method that straddles the natural and technological approaches and may hold promise within the farmland category as explained below.[49]

1. Forests

The trees and plants of a forest pull down carbon dioxide from the atmosphere and, as part of photosynthesis, increase the amount of carbon stored in the soil and in biomass.[50] Globally, forests comprise 92% of all terrestrial biomass, and the Pacific Northwest has some of the most carbon-dense forests in the entire world.[51] When forests are cut, they lose significant amounts of carbon—stored over decades or even centuries of life—and emit it directly into the atmosphere.[52] NCS strategies harnessing forests' immense power to store carbon generally include three methods: (1) conservation of

46. D.A. Bossio et al., *The Role of Soil Carbon in Natural Climate Solutions*, 3 NATURE SUSTAINABILITY 391, 391 (2020).

47. *Id.*; *see also* Griscom et al., *supra* note 24, at 11645.

48. *See* Rose A. Graves et al., *Potential Greenhouse Gas Reductions from Natural Climate Solutions in Oregon, USA*, 15(4) PLOS ONE, 1, Table 1 (Apr. 10, 2020).

49. *See* Johannes Lehmann & Angela Possinger, *Removal of Atmospheric CO_2 by Rock Weathering Holds Promise for Mitigating Climate Change*, 583 NATURE 204, 204-05 (2020).

50. *See* Rod Taylor et al., *What COP26 Means for Forests and the Climate*, WORLD. RES. INST. (Nov. 12, 2021), https://www.wri.org/insights/what-cop26-means-forests-climate [https://perma.cc/2DMF-E4T3] (noting that vast forest estates remain "globally important storehouses of carbon," storing more carbon than anything else but the oceans).

51. *Id.*; Beverly E. Law et al., *Land Use Strategies to Mitigate Climate Change in Carbon Dense Temperate Forests*, 115(14) PNAS 3663 (2018) [hereinafter Law et al., *Land Use Strategies*]; *see also* Mary Christina Wood, *The Oregon Forest Trust: An Ecological Endowment for Posterity*, 101 OR. L. REV. 515 at n. 57 and accompanying text (2023) [hereinafter Wood, *Oregon Forest Trust*].

52. *See* Statement of Dr. Beverly Law, *Wildfire in a Warming World: Opportunities to Improve Community Collaboration, Climate Resilience, and Workforce Capacity* 2, before the U.S. House of Representatives Subcommittee on National Parks, Forests and Public Lands (Apr. 29, 2021), https://www.congress.gov/117/meeting/house/112540/witnesses/HHRG-117-II10-Wstate-LawB-20210429.pdf ("More carbon is stored longer in forests than in wood products because about half of the harvested carbon is emitted soon after logging.").

forests; (2) reforestation of areas that have been cut; and (3) afforestation (foresting areas that have not been forests in recent history).[53]

Of these, the conservation approach holds the greatest potential to store carbon.[54] As one team of scientists explained, "[m]ature and old forests generally store more carbon in trees and soil than young forests, and continue to accumulate it over decades to centuries, making them the most effective forest-related climate mitigation strategy."[55] A recent study indicated that half of the living forest carbon stored above ground was in the largest (typically correlating with oldest) 1% of trees studied, and a study of Oregon forests similarly found that large (53 cm DBH or greater)[56] trees held 43% of the carbon despite comprising just 3% of the trees in the forest.[57] Even extending the harvest rotation of trees would result in increased storage during the time of deferred harvest.[58] Forests on private land are typically harvested well before they reach maturity, so extending the rotation period from the typical 40 years to 80 years would capture significantly more carbon until more permanent solutions can be found.[59] Scientists lament the logging practices that waste the potential of carbon-dense forests (such as the Westside forests in Oregon and Washington) to accumulate carbon, and they urge policies and practices that allow such forests to stand.[60] Conserving the forests also serves other purposes, including promoting biodiversity, protecting water sources, building climate resilience, and controlling erosion and overland flow.[61]

Reforestation can store only a third of the carbon that can be stored by forest conservation[62] but nevertheless provides impressive potential over time. On the global level, it is estimated that reforestation alone may accomplish as much as 10.1 GtC per year in drawdown potential if action is taken soon and proper management practices are employed to maintain the long-term health of forests.[63] Global reforestation potential exists on 0.9

53. Law et al., *Creating Strategic Reserves*, *supra* note 11.

54. *Id.* at 724 (providing a comparison estimating the potential of all three measures).

55. *Id.*

56. DBH refers to Diameter at Breast Height, a silvicultural standard for measuring trees.

57. Law et al., *Creating Strategic Reserves*, *supra* note 11, at 724.

58. Law et al., *Land Use Strategies*, *supra* note 51, at 3667; *see also* Kate Anderson, *Yes, Long Rotations Can Yield Real Climate Gains for Cascadia*, SIGHTLINE INST. (Mar. 17, 2022), https://www.Sightline.Org/2022/03/17/Yes-Long-Rotations-Can-Yield-Real-Climate-Gains-For-Cascadia/.

59. Law et al., *Creating Strategic Reserves*, *supra* note 11, at 722.

60. *Id.* at 723.

61. *See* Polly C. Buotte et al., *Carbon Sequestration and Biodiversity Co-Benefits of Preserving Forests in the Western United States*, ECOLOGICAL APPLICATIONS, Dec. 4, 2019, at 1, 6, https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.2039.

62. Law et al., *Creating Strategic Reserves*, *supra* note 11, at 723.

63. *See* Kelly Levin, *How Effective Is Land at Removing Carbon Pollution? The IPCC Weighs In*, WORLD RES. INST. (Aug. 8, 2019), https://www.wri.org/blog/2019/08/how-effective-land-removing-carbon-pollution-ipcc-weighs.

billion hectares across the world, and, once mature, may have the potential to remove as much as 25% of the current atmospheric carbon.[64] Of course, to fully capitalize on the potential that reforestation presents, further deforestation must end.[65] Lastly, afforestation accomplishes some carbon drawdown, but only about a tenth of the amount gained by conservation techniques.[66] Moreover, afforestation must be limited to areas that do not compete with other important societal uses like food production.

2. Farmlands

Agriculture provides other well-established pathways for carbon sequestration.[67] Regenerative agriculture, for example, seeks to capitalize on the soil's natural ability to store carbon.[68] This potential has been greatly diminished by destructive farming practices that trigger soil loss and degrade soil quality.[69] Over time, global soil stocks have lost as much as 150 GtC, but these soils, aided by regenerative agriculture practices, can be used to draw down as much as 4.8 GtC per year.[70] General principles guide the development of NCS on farmlands: (1) maximize continuously living roots; (2) minimize soil disturbance; (3) maximize biodiversity; and (4) maximize soil cover.[71] The agriculture NCS pathways include projects such as nutrient management, no-till or minimized-till practices, crop variation, cover-crop use, livestock and animal integration, precision irrigation, mulching, integrated pest management (IPM), agroforestry, and increased perennial

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64. *See* Jean-Francois Bastin et al., *The Global Tree Restoration Potential*, 365 SCIENCE 76, 79 (July 5, 2019), https://science.sciencemag.org/content/365/6448/76.

65. *See* Jeremy Hance, *Ending Deforestation Won't Stop Carbon Emissions from Land Use Change*, MONGABAY (Nov. 17, 2014), https://news.mongabay.com/2014/11/ending-deforestation-wont-stop-carbon-emissions-from-land-use-change/.

66. Law, *Creating Strategic Reserves*, *supra* note 11, at 723.

67. *See* RATTAN LAL ET AL., THE POTENTIAL OF U.S. CROPLAND TO SEQUESTER CARBON AND MITIGATE GREENHOUSE EFFECT 401 (1998) ("Sequestering soil [carbon] in grazing lands is important for enhancing soil and water quality and reducing the rate of emissions of radiatively active gases (greenhouse gases) to the atmosphere.").

68. *See* Judith D. Schwartz, *Soil as Carbon Storehouse: New Weapon in Climate Fight?*, YALE ENV'T 360 (Mar. 4, 2014), https://e360.yale.edu/features/soil_as_carbon_storehouse_new_weapon_in_climate_fight.

69. *Id.*

70. Pete Smith et al., *How to Measure, Report and Verify Soil Carbon Change to Realize the Potential of Soil Carbon Sequestration for Atmospheric Greenhouse Gas Removal*, 26 GLOB. CHANGE BIOLOGY 219, 220 (2020), https://doi.org/10.1111/gcb.14815. "Regenerative agriculture" is a broad term that not all farmers use, but it is a standard term used in NCS literature. For one rancher's elaboration of the term, *see Regenerative*, ALDERSPRING RANCH, https://www.alderspring.com/regenerative/ (last visited Mar. 2, 2024).

71. *Soil Health Principles*, CLIMATE HUBS, U.S. DEP'T OF AGRIC., https://www.climatehubs.usda.gov/image/soil-health-principles (last visited Mar. 2, 2024).

plantings.[72] Not only will these practices improve carbon drawdown, but many of them provide benefits to farmers and communities, such as more fertile soil and better water retention, which can boost crop productivity and help meet society's food demands.[73] Cover-crop usage, in particular, offers a number of significant benefits to producers yet is not widely implemented.[74]

Recent science points to another method that could be incorporated as an agricultural pathway. While far from honed and validated to the level necessary for regional adoption, a technique known as accelerated basalt weathering may have unique potential in some areas. Grinding basalt into small particles accelerates weathering of its primary minerals, launching chemical reactions that draw down atmospheric CO_2.[75] Such basalt could be added as a soil amendment to farmlands. The PNW region may have singular suitability for this potentially promising method as a result of its ample basalt geological stores, which provide local availability of silicate material (thus avoiding significant transportation-based emissions). Used as a soil amendment for PNW farmers, this method would not only sequester (in the soil) the added carbon from weathering but could also substitute for other soil amendments, such as lime, the production of which generates large emissions.[76]

3. Grasslands and Rangelands

In some regions, prairie systems contain far more soil organic carbon than other ecotypes due to the deep root systems and other characteristics of the grassland vegetation.[77] In America's Great Plains, for example,

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72. *Id.* (explaining the techniques); *see also* Graves et al., *supra* note 48; Griscom et al., *supra* note 24.

73. Mark A. Bradford et al., *Soil Carbon Science for Policy and Practice*, NATURE SUSTAINABILITY, Nov. 11, 2019, at 1, https://www.nature.com/articles/s41893-019-0431-y.

74. Cover crops may stabilize soil, reduce runoff, increase nutrients, and enhance soil carbon but in some cases may reduce crop yields. The outcome is dependent on the type of crop and the land characteristics. *See* Scott McFetridge, *Cover Crops Help the Climate and Environment, but Most Farmers Say No. Many Fear Losing Money*, AP (Nov. 2, 2023), https://apnews.com/article/cover-crops-farming-carbon-nitrogen-1648449f90b7072be50b95a21d733618.

75. For an explanation of the method, *see* Lucas C.R. Silva et al., *A Generalizable Framework for Enhanced Natural Climate Solutions*, 479 PLANT & SOIL 3, 11 (2022) (citing David J. Beerling et al., *Potential for Large-Scale CO_2 Removal via Enhanced Rock Weathering with Croplands*, 583 NATURE 242 (2020)); Peter Kelemen et al., *An Overview of the Status and Challenges of CO_2 Storage in Minerals and Geological Formations*, FRONTIERS CLIMATE, Nov. 15, 2019, at 1, 7 https://www.frontiersin.org/articles/10.3389/fclim.2019.00009/full.

76. Silva et al., *supra* note 75, at 12 (citing Johannes Lehmann & Angela Possinger, *Removal of Atmospheric CO_2 by Rock Weathering Holds Promise for Mitigating Climate Change*, 583 NATURE 204 (2020)).

77. *See Carbon Sequestration in Grasslands*, MINNESOTA BD. OF WATER & SOIL RES., https://bwsr.state.mn.us/carbon-sequestration-grasslands (last visited Dec. 12, 2023) (explaining that prairie grasslands have adapted to fire and grazing by retaining more carbon).

grasslands and shrublands hold 34% of all the carbon stored in the region.[78] Thus, a broad category of NCS focuses on both the natural grasslands and the rangelands on which livestock roam. An important strategy is to avoid conversion of natural prairies to cropland or pastures, both of which can release carbon.[79] Other pathways seek to restore sagebrush-steppe systems, which can also boost habitat for species.[80] To achieve the natural potential of these areas, encroachments must be monitored and thwarted—both human-caused (such as urban sprawl) and Nature-caused (such as juniper and other invasive-species intrusion).

On rangelands and grazed grasslands, overgrazing has significantly decreased above-ground biomass carbon.[81] Accordingly, much of the NCS techniques in this category focus on reforming grazing practices[82] and deploying methods that move livestock frequently.[83] Moving livestock leaves more vegetation on rangeland, which in turn can promote carbon drawdown and storage.[84] Methods include creating long intervals without grazing to promote strong root systems and practicing more intensive grazing for shorter periods to support plant growth.[85] Some also suggest mimicking historic natural grazing processes of wild ungulates like buffalo to restore carbon and important nutrients to barren, overgrazed grasslands and pasturelands.[86] Ranchers are innovating new practices tailored to their unique land base. In Idaho, the Alderspring Ranch has instituted a practice of "inherding," described as "a unique management of cattle on extensive wild

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78. *Id.*

79. Graves et al., *supra* note 48, at 7.

80. *Id.* at 12.

81. *See* J. Boone Kauffman et al., *Livestock Use on Public Lands in the Western USA Exacerbates Climate Change: Implications for Climate Change Mitigation and Adaptation*, 69 ENV'T MGMT. 1137, 1137 (2022) ("[Domestic livestock] defoliate native plants, trample vegetation and soils, and accelerate the spread of exotic species[,] resulting in a shift in landscape function from carbon sinks to sources of greenhouse gases. . . .").

82. *Id.*

83. *See* Benjamin Ryan, *Keeping Cattle on the Move and Carbon in the Soil*, N.Y. TIMES (Oct. 31, 2021), https://www.nytimes.com/2021/10/31/climate/cows-grassland-carbon.html (explaining that livestock ranchers who practice regenerative grazing keep their herds concentrated and move them often to support soil health).

84. *See id.* (explaining that regenerative grazing encourages livestock to consume different types of grasses, leaving a variety of plant species in place after the livestock has grazed)*; see also* Lina Aoyama et al., *Using Ecological Site Descriptions to Make Ranch-Level Decisions About Where to Manage for Soil Organic Carbon*, 76 CAL. AGRIC. 85, 91 (2022) (emphasizing that site-specific variables should form basis of plans).

85. *See Rotational Grazing for Climate Resilience*, CLIMATE HUBS, U.S. DEP'T OF AGRIC., https://www.climatehubs.usda.gov/hubs/international/topic/rotational-grazing-climate-resilience (last visited Mar. 2, 2024) (explaining how rotational grazing's frequent movement allows plants to rest and regrow to grazing height while livestock graze other paddocks, and that the length of grazing and rest periods is ecosystem dependent and differs depending on forage yield).

86. *See* Darrell J. Bosch et al., *Farm Returns to Carbon Credit Creation with Intensive Rotational Grazing*, 63 J. SOIL & WATER CONSERVATION 91, 91 (2008) (explaining that rotational grazing systems produce soil health benefits).

rangelands" in which "[a]ll cattle on the entire landscape are managed as a single controlled group, and penned each night near a cow camp."[87] In-herding not only promotes carbon sequestration but also eliminates wolf conflicts (by having human presence) and restores riparian habitat for salmon (by keeping cattle away from streams).[88]

If the potential for restorative grazing is fully met, some researchers project that nearly 295 million metric tons of CO_2 could be stored in the soils globally each year.[89] Nevertheless, NCS techniques in this category stir scientific controversy concerning the methane emissions associated with cattle production.[90] About 20% of the total anthropogenic methane release in the U.S. is attributable to cattle production.[91] However, the methane releases may be substantially tied to the animal's time spent in feedlots to "finish" the animal prior to slaughter.[92] Nearly 95% of cattle in the U.S. are fattened in their last stage of life on grain-based diets characteristic of feedlots, while only about 5% are grass-finished, spending their entire lives on pasture.[93] Scientists are evaluating methane emissions associated with adaptive management techniques deployed for livestock spending their entire lives feeding on grasses.[94]

4. Blue and Teal Carbon Areas

Blue and teal carbon ecosystems provide a fourth reservoir for atmospheric carbon. The term "blue-carbon" refers to coastal and marine

87. *See* ALDERSPRING RANCH, *supra* note 70.

88. *Id.*

89. Benjamin B. Henderson et al., *Greenhouse Gas Mitigation Potential of the World's Grazing*, 207 AGRIC., ECOSYSTEMS & ENV'T 91, 98 (2015). The estimate is premised on grazing reform combined with legume sowing and fertilization practices, which entail risk of N_2O emissions that can offset the gains from reduced carbon emissions. *Id.* The authors emphasize the need for more research to "identify amenable areas, based on their biophysical and management attributes, to avoid sowing of legumes in pasturelands with the potential for large increases in soil based GHG emissions." *Id.* The call for more localized research underscores the need for Regional Frameworks that can identify suitable lands for regenerative grazing.

90. *See* Kate Lajtha & Lucas Silva, *Grazing Cattle, Well-Managed or Not, Is Unlikely to Increase Soil Carbon Sequestration*, PNAS, July 6, 2022, at 1, 2, https://www.pnas.org/doi/epdf/10.1073/pnas.2203408119.

91. Joseph Mangino et al., *Development of an Emissions Model to Estimate Methane from Enteric Fermentation in Cattle*, EPA, https://www3.epa.gov/ttnchie1/conference/ei12/green/mangino.pdf (last visited Jan. 10, 2024); *see also* Amy Quinton, *Cows and Climate Change*, U.C. DAVIS (June 17, 2019), https://www.ucdavis.edu/food/news/making-cattle-more-sustainable (noting that scientists are developing seaweed dietary supplements for beef cattle to significantly reduce the methane emissions).

92. Christopher D. Lupo et al., *Life-Cycle Assessment of the Beef Cattle Production System for the Northern Great Plains, USA*, 42 J. ENV'T QUALITY 1386, 1386 (2013).

93. Allison Kosto, *The Complexities of Grass Fed Beef*, MONT. STATE UNIV. EXTENSION (Mar. 18, 2022), https://www.montana.edu/extension/broadwater/blog-article.html?id=21908.

94. Paige L. Stanley et al., *Impacts of Soil Carbon Sequestration on Life Cycle Greenhouse Gas Emissions in Midwestern USA Beef Finishing Systems*, 162 AGRIC. SYS. 249, 255 (2018).

ecosystems, including intertidal marshes, coastal estuaries, seagrass beds, and in some parts of the world, mangroves.[95] Blue-carbon ecosystems are structured around highly productive plant species which pull carbon from the atmosphere and trap it in sediments.[96] These ecosystems may sequester carbon at higher proportional rates than forests and for longer periods of time.[97] Despite covering only 2% of the ocean's surface area, blue-carbon ecosystems have gained significant attention for their contribution to NCS global drawdown potential.[98] For intact natural blue-carbon areas, NCS focuses on avoided conversion, i.e., conservation and permanent legal protection.[99]

Blue-carbon sinks have been destroyed and degraded worldwide. For example, in Oregon alone, over half of the historic tidal wetlands have been lost since Oregon attained statehood.[100] In Washington's Puget Sound, 80% of tidal wetlands have disappeared.[101] For these ecosystems, NCS approaches focus on restoration. Strategies often involve the removal of dikes and other structures that have impeded tidal flows.[102] When the tides return, marshes may revive with restored sediment accretion, pH, water salinity, and nutrient and organic-matter content.[103]

Marine scientists also focus on the carbon sequestration benefits of nearshore ecosystems like seagrass, kelp forests, algae beds, and coastal

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95. *Protecting Coastal Blue Carbon Through Habitat Conservation*, NOAA FISHERIES (Oct. 25, 2022), https://www.fisheries.noaa.gov/national/habitat-conservation/protecting-coastal-blue-carbon-through-habitat-conservation [hereinafter *Protecting Coastal Blue Carbon*].

96. Sofia Metzler Concepción, *What Is Blue Carbon?*, SUSTAINABLE OCEAN ALL. (Feb. 28, 2022), https://www.soalliance.org/soablog/what-is-blue-carbon.

97. *See Blue Carbon Science & Projects: Carbon Stored and Sequestered by Coastal Wetlands*, RESTORE AM.'S ESTUARIES, https://estuaries.org/bluecarbon/blue-carbon-science-projects/ (last visited Sept. 23, 2022) (demonstrating that, in the first meter of soil, seagrass contained approximately double the amount of Mg CO_2e/ha as a tropical forest).

98. *See What You Need to Know About Blue Carbon*, WORLD BANK (Nov. 21, 2023), https://www.worldbank.org/en/news/feature/2023/11/21/what-you-need-to-know-about-blue-carbon; (explaining that blue-carbon coastal ecosystems account for 50% of the ocean's carbon absorption); Micheli Duarte de Paula Costa & Peter I. Macreadie, *The Evolution of Blue Carbon Science*, 42 WETLANDS 109 (2022).

99. *See Protecting Coastal Blue Carbon*, *supra* note 95.

100. Andy Kerr, *Oregon's Blue Carbon, Part 2: Coastal Wetland Loss and Restoration*, ANDY KERR'S PUB. LANDS BLOG (July 9, 2021), https://www.andykerr.net/kerr-public-lands-blog/2021/7/9/oregons-blue-carbon-part-2-coastal-wetland-loss-and-restoration.

101. *See* BRIAN D. COLLINS & AMIR J. SHEIKH, HISTORICAL RECONSTRUCTION, CLASSIFICATION, AND CHANGE ANALYSIS OF PUGET SOUND TIDAL MARSHES 73 (2005) (describing how tidal wetlands in Puget Sound have disappeared compared to the pre-Euro-American settlement levels).

102. *See* Kevin D. Kroger et al., *Restoring Tides to Reduce Methane Emissions in Impounded Wetlands: A New and Potent Blue Carbon Climate Change Intervention*, SCI. REPS., Sept. 20, 2017, at 1, 2, https://www.nature.com/articles/s41598-017-12138-4 (explaining that tidal restoration includes removing water-impeding technology so water can return to its natural level and salinity).

103. CHRISTOPHER JANOUSEK ET AL., EARLY POST-RESTORATION RECOVERY OF TIDAL WETLAND STRUCTURE AND FUNCTION AT THE SOUTHERN FLOW CORRIDOR PROJECT, TILLAMOOK BAY, OREGON 25 (Research Gate 2021).

dunes.[104] Plants in these ecosystems accumulate carbon rapidly and, due to their slower decomposition, hold the carbon for longer periods of time compared to terrestrial carbon.[105] Kelp forests, a subcategory of these blue-carbon stocks, may store as much as 7.5 to 20 teragrams of carbon.[106] Approximately 10% of the kelp will be shed and reach the deep sea, where it can store carbon for the long term.[107] Restoring lost kelp forests entails seeding and cultivating areas and controlling urban runoff and other ocean pollution.[108]

Beyond carbon storage, healthy blue-carbon ecosystems provide several key co-benefits. The physics of healthy vegetation in blue-carbon systems dampens wave energy as it pushes toward the coast, thereby offering protection from storm surge and associated flooding, erosion, and resulting property damage.[109] Additionally, blue-carbon ecosystems provide crucial nurseries for many marine species, support coral reefs, and help combat ocean acidification.[110] Coastal vegetation also filters runoff, trapping and processing pollutants in vast, tangled root systems to purify water as it flows back into the ocean.[111]

The teal carbon ecosystems—inland wetlands, marshes, and swamps—are also vital sinks. Wetlands may hold between 20–30% of global terrestrial carbon, yet they occupy just 5–8% of the planet's land-surface area.[112]

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104. *See, e.g.*, *How Seagrass and Kelp Support Habitats' Resilience in a Changing Ocean*, MONTEREY BAY AQUARIUM, https://www.montereybayaquarium.org/stories/seagrass-kelp-help-climate-change-ocean-acidification (explaining that seagrass can help fight ocean acidification); *see generally* Vishal Paul et al., *Role of Algae in CO_2 Sequestration Addressing Climate Change: A Review*, *in* RENEWABLE ENERGY & CLIMATE CHANGE 257, 257–65 (2019).

105. Jill T. Greiner et al., *Seagrass Restoration Enhances "Blue Carbon" Sequestration in Coastal Waters*, PLOS ONE, Aug. 14, 2013, at 1, 1, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0072469.

106. DANIEL M. ALONGI, BLUE CARBON: COASTAL SEQUESTRATION FOR CLIMATE CHANGE MITIGATION 2, 36 (2017).

107. Dorte Krause-Jensen & Carlos M. Duarte, *Substantial Role of Macroalgae in Marine Carbon Sequestration*, 9 NATURE GEOSCIENCE 737, 738–39 (2016).

108. *See Planting Hope: Seagrass*, WORLD WILDLIFE FUND UK, https://www.wwf.org.uk/what-we-do/planting-hope-how-seagrass-can-tackle-climate-change (last visited Dec. 12, 2023) (describing seagrass-restoration projects in the UK).

109. *See* MARK SPALDING ET AL., WETLANDS INT'L & NATURE CONSERVANCY, MANGROVES FOR COASTAL DEFENCE: GUIDELINES FOR COASTAL MANAGERS & POLICY MAKERS 16 (2014), https://www.nature.org/media/oceansandcoasts/mangroves-for-coastal-defence.pdf (explaining that mangroves lessen wave damage during intense weather events).

110. *See Kelp and Ocean Acidification*, WASH. SEA GRANT, https://wsg.washington.edu/wordpress/wp-content/uploads/Kelp_Brochure.pdf (last visited Dec. 12, 2023) (illustrating the benefits of blue-carbon systems to ocean acidification).

111. *Why Are Estuaries Important? Ecosystem Services*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., https://oceanservice.noaa.gov/education/tutorial_estuaries/est03_ecosystem.html (last visited Feb. 29, 2024).

112. Amanda M. Nahlik, *Importance of Teal Carbon to Wetland Carbon Monitoring and Assessment*, NASA, https://cce-

Globally, a fifth of natural wetlands have been destroyed.[113] While wetlands are considered part of an NCS strategy, they also release methane and nitrous oxide, both potent greenhouse gases.[114] NCS strategies focus on conserving natural, undisturbed wetlands and restoring the hydrology and other functions of disturbed wetlands.[115] Functioning wetlands provide a myriad of benefits, including flood control, water purification, water storage (and increased supply), bank stabilization, fish and wildlife habitat, and recreational amenities.[116] These areas are particularly crucial to biodiversity, as a third of imperiled species listed under the Endangered Species Act rely on wetland habitat.[117]

II. A META-STRATEGY FOR ORGANIZING SKY CLEANUP

In a functional political world, national leaders around the globe would create a vision and framework for a global collaborative supporting sufficient carbon drawdown and biodiversity recovery. Regional and local governments would follow through on these commitments by coalescing a land management movement to the four corners of their jurisdictions. But while international and U.S. ambition for carbon drawdown is growing, there has been no broad follow-through on the regional and local levels. Even as the science proceeds at a rapid pace, demonstrating the potential of NCS for mitigation, a gap widens between the science and on-the-ground application. Much of the research stops at the conceptual stage and does not proceed into the next phase of designing implementation pathways. Though proof of concept occurs through scattered pilot projects, these lack a framework to bring the techniques to scale. An organizing nucleus is necessary to identify the data, protocols, and tools needed so that working-land professionals may implement, monitor, and continue to refine carbon-sequestration techniques.

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datasharing.gsfc.nasa.gov/files/conference_presentations/Talk_Nahlik_49_29.pdf (last visited Dec. 12, 2023).

113. Eric Roston, *A Fifth of the World's Species-Rich Wetlands Have Been Destroyed*, BLOOMBERG (Feb. 8, 2023), https://www.bloomberg.com/news/articles/2023-02-08/a-fifth-of-the-world-s-species-rich-wetlands-have-been-destroyed?leadSource=uverify%20wall.

114. Martino E. Malerba et al., *Methane and Nitrous Oxide Emissions Complicate the Climate Benefits of Teal and Blue Carbon Wetlands*, 5 ONE EARTH 1336, 1336 (2022), https://www.sciencedirect.com/science/article/pii/S2590332222005796/pdfft?md5=02cb45e7852bba64 34f8746eb0a0ee9d&pid=1-s2.0-S2590332222005796-main.pdf.

115. *Id.* at 1338 ("Natural wetlands are best left undisturbed to conserve long-term carbon storage and maintain a net cooling effect on the atmosphere. Conversely, disturbed wetlands require active management to lessen their impacts on climate change and improve other essential benefits, including biodiversity, cultural significance, flood protection, and drought resilience. Typical management actions for controlling GHG emissions are restoring natural hydrology, revegetation, and reducing eutrophication.").

116. *Why Are Wetlands Important?*, NAT'L PARK SERV., https://www.nps.gov/subjects/wetlands/why.htm# (May 5, 2016).

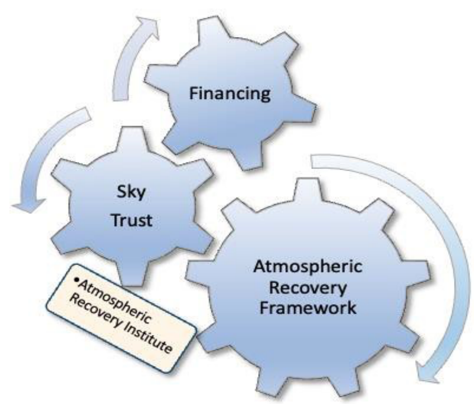
117. *Id.*

Financing must materialize to induce landowners and land managers to adopt these practices. Finally, a new form of institution must emerge to develop projects and implement them across the landscape rapidly and effectively.

The drawdown project must be defined regionally, incorporating enough jurisdictions to make the project practical. While ideally tied to a national strategy, a regional blueprint can capture the scale necessary for landscape restoration and minimize inefficiencies caused by smaller efforts. It also provides opportunities for collaboration between neighboring sovereigns. While a region may encompass varied ecosystems, all with their own complexity, a regional strategy remains manageable in terms of ecological differentiation. But even on a regional scale, harnessing NCS capabilities and equipping communities to pursue restoration projects is a massive undertaking.

A. The Three-Gear Approach

The urgent project of catalyzing and sustaining a regional atmospheric recovery effort requires a rapid coalescence of legal frameworks, financing, land-management decisions, scientific expertise, and community buy-in. This Article offers a meta-strategy that takes shape around a three-gear design suitable for deployment on the regional level—wherever NCS opportunity exists. By providing a common strategy between regions, the three-gear approach aims to catalyze a global effort that is uniquely localized, yet formidably unified and urgent in its principled resolve.



This approach anticipates an iterative endeavor, not structured in the familiar style of top-down regulation but rather designed to harness incentives and expertise to create opportunity. Envisioned as interlocking "gears," momentum on any one gear may propel the other gears as well. The three gears driving regional atmospheric recovery are: (1) the Atmospheric Recovery Framework; (2) the Financing; and (3) the Sky Trust.[118] Ideally, this structure would replicate across different regions of the nation—or even the world—simultaneously.

1. The Regional Framework

The Framework provides the first "gear" in the meta-strategy. It presents a conceptual template to organize and recruit communities into a broad regional enterprise of restoration and drawdown. Broadly speaking, the Framework is a synthesis research endeavor that aggregates and characterizes the ongoing initiatives and NCS potential across a region. The Framework should not reinvent the wheel or duplicate work being done but instead should offer a coherent organizing platform for situating presently disconnected efforts—and thereby draw synergy from them.[119] The Framework should identify gaps, needs, and scientific uncertainties.

As a key point, the Framework is neither government-initiated nor government-enforced. Governments have thus far failed to move with all deliberate speed on the urgent climate front, and some observers point to the need for new organizing institutions and approaches.[120] The Framework is devised through a transdisciplinary effort involving scientists, economists, conservation lawyers, land managers, and community and youth leaders. It aims to match the sequestration potential of a jurisdiction with the resources, needs, and incentives of the local communities positioned to undertake restoration. As a tangible and operable blueprint for restoration, the Framework will map and define key areas of sequestration potential, estimate costs of NCS projects, announce opportunities across landscapes using techniques in all four ecotypes of natural climate solutions, and address barriers and justice issues. By capturing a region's NCS potential, the Framework represents the necessary first step in region-wide NCS restoration. Part III below describes the specific components of regional

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118. *See* Mary Christina Wood, *Atmospheric Recovery Litigation: Making the Fossil Fuel Companies Pay for Cleaning Up the Atmosphere*, *in* BEARING WITNESS: THE HUMAN RIGHTS CASE AGAINST FRACKING AND CLIMATE CHANGE 285, 290–94 (Thomas A. Kerns & Kathleen Dean Moore eds., 2021) (describing in detail the three driving gears of regional atmospheric recovery).

119. *See Natural & Working Lands Proposal 2021*, OR. GLOB. WARMING COMM'N 9, https://static1.squarespace.com/static/59c554e0f09ca40655ea6eb0/t/6148a9d36431174181e05c7c/1632 15 2029009/2021+OGWC+Natural+and+Working+Lands+Proposal.pdf (describing work of the Oregon Global Warming Commission's Natural and Working Lands Advisory Committee in developing a methodology for carbon sequestration across Oregon that would either directly plug into or inform a PNW-FAR); *see also infra* Part IV (discussing the PNW-FAR as part of an accelerated, scaled-up regional approach devised outside of government processes).

120. *See* Matto Mildenberger, *The Development of Climate Institutions in the United States*, 30 ENV'T POL. 71, 83–88 (2021) (discussing the different periods of climate change institutions in America, their shortcomings, and how to overcome them).

Frameworks in more detail. Notably, the Frameworks will constantly evolve as NCS knowledge and experience mount. Therefore, as a practical matter, while regional Frameworks begin as written guides, they must quickly become iterative web-based resources that are publicly accessible and readily updated and revised.

2. Atmospheric Natural Resource Damages and Other Financing

A second "gear" of the meta-strategy focuses on financing atmospheric cleanup NCS projects. Recognizing that a transformative project of this scale can only be jump-started and sustained with major funding,[121] this gear develops funding avenues gained from various sources. Funds will provide financial incentives to land managers to engage in carbon forestry, regenerative farming, carbon ranching, and blue and teal carbon restoration. This gear anticipates a diverse assortment of funding sources, including government programs and private philanthropy. Importantly, it also turns the spotlight to one particularly obvious "deep pocket" that has not yet been tapped for any climate cleanup: the fossil-fuel industry.

Access to deep financing by fossil-fuel corporations may be gained through a theory of legal liability for natural-resource damages (NRDs). Bearing a strong analogy to marine oil spills, a new form of litigation (Atmospheric NRD Litigation) would seek to hold fossil-fuel companies accountable for polluting the atmosphere with carbon in the same way that oil companies are held accountable for cleaning up marine oil spills. The approach would use damages paid by defendants to fund climate mitigation—cleaning up the excess atmospheric carbon dioxide that is fueling climate disruption. While the marine oil-spill cases typically invoke statutory grounds for liability (and there is no equivalent statutory authority for an atmospheric-pollution suit), a robust line of emerging case law holds chemical manufacturers responsible for financing cleanup of polluted natural resources under common-law (non-statutory) theories grounded in the

121. *See* Minal Pathak et al., Intergovernmental Panel on Climate Change, Climate Change 2022: Mitigation of Climate Change, Technical Summary, 51, 108–09 (2022) (indicating the need for more funding sources beyond government grants to promote landscape sequestration and noting that "[f]inance forms a critical barrier" for such efforts).

public-trust and public-nuisance doctrines.[122] Under an existing approach,[123] sovereign entities (foreign nations, federal agencies, states, counties, and tribes) stand positioned to invoke these same grounds to pursue Atmospheric NRD Litigation against the fossil-fuel industry to fund sky carbon cleanup projects within the applicable Regional Frameworks for Atmospheric Recovery. Because this litigation strategy is based on the standard model of cleaning up an oil spill, fossil-fuel corporations themselves are likely to foresee it.[124]

Another line of litigation against fossil-fuel companies, quickly gaining momentum, offers another potential source of major financing. Over two dozen lawsuits have been filed by cities, counties, and states against carbon majors, primarily to fund adaptation costs.[125] These plaintiff sovereigns are constitutionally charged by virtue of their police power to provide for public health and safety. Yet they cannot do so in the face of soaring costs caused by climate disasters. In effect, fossil fuels, by contributing to the disruption of Earth's energy imbalance, have also upended the infrastructure that cities, counties, and states rely on to provide for the general welfare.[126] Some of the adaptation lawsuits seek full "disgorgement of profits" from the fossil-fuel defendants.[127] These cases against Climate Liable Parties[128] rest on producer liability. They assert state common-law claims, and all have a centerpiece public-nuisance claim, with several presenting additional claims sounding in product liability and negligence.[129] These suits have established important

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122. *See* Mary Christina Wood, *Atmospheric Recovery Litigation Around the World: Gaining Natural Resource Damage Awards Against Carbon Majors to Fund a Sky Cleanup for Climate Restoration*, *in* RESEARCH HANDBOOK ON CLIMATE CHANGE LAW AND LOSS & DAMAGE 303, 307–09, 320–23 (Meinhard Doelle & Sarah L. Seck eds., 2021) [hereinafter Wood, HANDBOOK] (explaining the public trust doctrine and common law causes of action such as nuisance and trespass, and how each can be used as a framework for litigating pollution of the atmosphere).

123. *See id.* at 312–20 (applying common law causes of action under the public trust doctrine and theories of nuisance and trespass to atmospheric pollution to identify which parties would be liable for pollution of the atmosphere under these theories and the potential claims); *see also* Mary Christina Wood & Daniel Galpern, *Atmospheric Recovery Litigation: Making the Fossil Fuel Industry Pay to Restore a Viable Climate System*, 45 ENV'T L. 259, 297–320 (2015) (describing how the public trust doctrine gives sovereign entities the authority to pursue Atmospheric NRD litigation).

124. *See* Ira Gottlieb et al., *Natural Resource Damages for Climate Change—An Idea Whose Time Is Not Yet Come, Part I: NRD Claims Are Not Currently Viable Under CERCLA*, 20(4) ENV'T CLAIMS J. 256, 256–57 (2008) (acknowledging that "it may only be a matter of time before natural resources trustees file actions for NRD[s] based upon climate change effects").

125. Patrick Parenteau & John Dernbach, *More than Two Dozen Cities and States Are Suing Big Oil over Climate Change – They Just Got a Boost from the US Supreme Court*, CONVERSATION (May 23, 2023), https://theconversation.com/more-than-two-dozen-cities-and-states-are-suing-big-oil-over-climate-change-they-just-got-a-boost-from-the-us-supreme-court-205009.

126. *Id.*

127. Wood, HANDBOOK, *supra* note 122, at 306.

128. *See id.* at 314 (originating the term "Climate Liable Parties" to broadly categorize all defendants, not just fossil-fuel defendants, in climate litigation, a term roughly analogous to Potentially Responsible Parties (PRPs) in the hazardous waste realm).

129. *Id.* at 306.

cornerstones of sky cleanup by pursuing crucial evidence of industry culpability and crafting legal approaches to industry liability. They allege jaw-dropping factual characterizations of what the companies knew would be the damage likely caused by their continued fossil-fuel production.[130] While these suits have been tangled in judicial removal issues for years, appellate courts have recently allowed such suits to proceed under state-law theories.[131]

Recent complaints in suits filed against fossil-fuel companies by Multnomah County, Oregon and the State of California ask the respective courts for abatement funding to finance necessary adaptation to the heating world.[132] Such funds can represent a massive infusion of money—the Multnomah County complaint, for example, seeks $50 billion.[133] Broadly speaking, the remedy sought in adaptation lawsuits can be thought of as financing a bifurcated set of responses: (1) "engineered adaptation," such as seawalls, new roads, and cooling centers; and (2) "natural adaptation," which deploys natural climate solutions.

Nearly all natural climate solutions have an adaptation benefit. Protecting forests secures water supplies in a drought-stricken region. Increasing soil carbon allows more water storage and guards against the parched conditions that farmers increasingly face. In-herding livestock keeps cattle away from streams, thereby restoring essential riparian functions needed by salmon and other species to survive in warmer waters. Reconnecting historic tidal estuaries with their natural water sources protects against flooding and storm surges. Proceeding apace, these lawsuits could present a potential funding mechanism for NCS. Nevertheless, the costs of such natural adaptation measures must be clearly delineated if such measures are to gain attention at the remedy stage of adaptation litigation. The Framework is necessary to earmark such natural adaptation measures in a manner that will be recognizable to the courts.

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130. *See, e.g.*, Complaint at 2, Cnty. of Multnomah v. Exxon Mobil Corp., (Or. Cir. Ct. 2023) (No. 23CV25164) (asserting common-law claims to seek damages for fossil-fuel companies' "scheme to rapaciously sell fossil-fuel products and deceptively promote them as harmless to the environment, while they knew that carbon pollution emitted by their products into the atmosphere would likely cause deadly extreme heat events like that which devastated Multnomah County . . .") [hereinafter Multnomah County Complaint].

131. *See* Jonathan Adler, *D.C. Circuit Rejects Oil Company Attempt to Remove District's Climate Suit to Federal Court*, REASON (Dec. 19, 2023), https://reason.com/volokh/2023/12/19/d-c-circuit-rejects-oil-company-attempt-to-remove-districts-climate-suit-to-federal-court/ (reporting on the decision in *District of Columbia v. Exxon Mobil Corporation* to remand the case back to the state court system and allow it to proceed there under state and common-law causes of action).

132. *See* Multnomah County Complaint, *supra* note 130, at 174; Rebecca Picciotto, *California Suit Against Chevron, Exxon, Shell, Others, Alleges Public Deception on Climate Change*, CNBC (Sept. 18, 2023), https://www.cnbc.com/2023/09/18/california-sues-chevron-exxon-oil-giants-on-climate-change-deception.html.

133. Multnomah County Complaint, *supra* note 130, at 174.

Even apart from contemplated atmospheric NRD suits and adaptation lawsuits that may yield NCS financing, many other environmental suits often settle for large sums of penalty money that is then put into various environmental-mitigation funds.[134] Such funds may support a variety of environmental projects,[135] and presumably, such pollution settlements can direct funds toward financing atmospheric cleanup. This would be most suitable where opportunity mapping (developed in the Framework described below) shows a co-benefit from the drawdown project to the damaged environmental resource. For example, a defendant corporation settling a case for river pollution may agree to dedicate the settlement money to a forest-carbon project that also improves water quality in the river basin.

In sum, multiple avenues exist for funding the Framework. Some are well established, while others involve litigation that has not yet been brought. Funders may include defendants in climate or other pollution litigation, philanthropic organizations, or government agencies with funding programs. Once a Regional Framework is in place, it is expected to draw some funding streams to atmospheric cleanup that would otherwise go elsewhere.

3. The Sky Trust

The regional project of atmospheric drawdown requires an administrative structure to accept funds, solicit projects, create eligibility requirements, dispense the funding, and supervise the completion of work. A third gear envisions a funding entity (or regional Sky Trust) that undertakes these functions and essentially serves as the institutional broker for landscape NCS projects under the Framework. Many landowners and organizations seeking to participate in carbon sequestration describe a barrier of cumbersome and fragmented funding processes.[136] The regional Sky Trust would aggregate funders, facilitate landowner participation, and help match

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134. These suits may arise, for example, under citizen suit provisions of pollution statutes like the Clean Air Act and Clean Water Act. *See, e.g.*, *Enforce the Law*, COLUMBIA RIVER KEEPER, https://www.columbiariverkeeper.org/stopping-pollution/law (last visited Mar. 29, 2024) ("As part of the lawsuit settlement, the penalty funds support projects by other organizations that benefit water quality.").

135. *See Puget Sound Stewardship & Mitigation Fund*, ROSE FOUND., https://rosefdn.org/puget-sound-stewardship-mitigation-fund/ (last visited Mar. 29, 2024) (reporting that funds gained from environmental litigation are used to support projects relating to "conservation, restoration, citizen science, environmental justice, shoreline access, and environmental education.").

136. *See generally* Puskar N. Khanal et al., *Obstacles to Participation in Carbon Sequestration for Nonindustrial Private Forest Landowners in the Southern United States*: *A Diffusion of Innovations Perspective*, 100 FOREST POL'Y & ECON. 95 (2019) (identifying through survey the major obstacles forest landowners face when attempting to participate in carbon sequestration market programs); *see also* Melissa Kreye & Calvin Norman, *What Is Selling Forest Carbon Like? Three Landowners' Experiences*, PENN STATE EXTENSION (2021), https://extension.psu.edu/what-is-selling-forest-carbon-like-three-landowners-experiences (describing case studies of landowners considering and navigating different forest carbon sequestration market programs and the hurdles they sometimes encountered).

projects with financial opportunities to accelerate and scale up regional sequestration. Where sponsoring organizations, such as land trusts or tribes, exist for projects, the Sky Trust may provide partnership capacity to carry out carbon sequestration. The Sky Trust may be an existing or newly created institution, but it must have the administrative capability and organizational competence to handle funds; approve or co-design projects; enter into contracts with landowners; negotiate the necessary conservation easements or covenants (to provide durability of sequestered carbon); administratively supervise completion of NCS projects; carry out monitoring; and seek third-party verification of key project components.

Several national models exist for a restoration-focused trust, including four discussed below that were established and supervised by courts. These judicially established trusts may have aspects that will prove instructive for disbursing the abatement funds sought by plaintiff sovereigns or sub-sovereigns in current litigation against fossil-fuel defendants. In litigation arising from the illegal installation of faulty emissions controls on automobiles, defendant Volkswagen AG, Inc. (VW) and the U.S. Department of Justice entered into a multistage, multi-billion dollar settlement to mitigate the tons of NO_x pollution caused by VW's alleged wrongdoing.[137] The court ordered VW to pay $2.9 billion into an Environmental Mitigation Trust and appointed an independent trustee to administer the funds to finance projects across states, territories, and Indian reservations based on the number of affected vehicles sold in their jurisdictions.[138] Another model emerges from the BP oil spill, which discharged millions of barrels of oil into the Gulf of Mexico across an area larger than the State of Idaho.[139] As part of a $20-billion settlement with the U.S. Department of Justice, BP paid $7.1 billion to the Deepwater Horizon Oil Spill NRD Fund.[140] The Department of the Interior manages this fund for the joint purpose of cleaning up oil and restoring natural resources in the

137. *Volkswagen Clean Air Act Civil Settlement*, EPA, https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement (Jan. 23, 2024).

138. *Id.*; *Volkswagen (VW) Settlement: DERA Option*, EPA, https://www.epa.gov/dera/volkswagen-vw-settlement-dera-option (Apr. 28, 2023); Jim Motavalli, *How VW's Diesel Settlement is Changing Fleets, From Schools to Seaports,* N.Y. TIMES (Sept. 22, 2021), https://www.nytimes.com/2020/11/05/business/vw-diesel-settlement-states.html.

139. *See U.S. and Five Gulf States Reach Historic Settlement with BP to Resolve Civil Lawsuit Over Deepwater Horizon Oil Spill*, U.S. DEP'T OF JUST. (Oct. 5, 2015), https://www.justice.gov/opa/pr/us-and-five-gulf-states-reach-historic-settlement-bp-resolve-civil-lawsuit-over-deepwater (describing the $20.8 billion settlement between the U.S. Department of Justice and B.P. for damages caused by an oil spill of "more than three million barrels of oil into the Gulf of Mexico . . . extend[ing] across more than 43,000 square miles").

140. *Id.*

jurisdictions of five Gulf state trustees.[141] A third model comes from litigation brought by the State of California and several counties against lead-paint manufacturers that resulted in a $305 million settlement.[142] The court ordered funds to be used to remove lead paint from affected homes under a four-year program supervised by the state of California and those counties.[143] A final model arises from litigation that ensued after a pipeline explosion in Bellingham, Washington killed three young boys in 1999.[144] At the behest of the boys' families and local leaders, the presiding federal district-court judge directed $4 million in criminal fines to endow a new Pipeline Safety Trust, a non-profit organization created to promote pipeline safety through research, outreach, education, and advocacy.[145]

While these four examples derive from litigation settlements, a Sky Trust could also be created by sovereigns or even non-profit groups. Regardless of its origin, the Sky Trust must display efficiency, credibility, and scrupulous transparency to justify confidence on the part of private funders, courts, and the public in the Trust as the primary apparatus for implementing the drawdown vision in the region for the century (or longer) it will take to regain balance of the planet's climate system. Moreover, in a departure from traditional failed models of environmental decision-making, the Trust should have a representative of the future dedicated to assessing the impact of today's decisions on both young people and future generations.[146]

B. Not an Offset Program

A Regional Framework for Atmospheric Recovery guides active land management to maximize the region's contribution towards drawdown of legacy carbon, which will be necessary to return atmospheric concentrations to below 350 ppm and thereby regain climate stability. To be clear, this is not an offset program but rather a sky cleanup program. Many governments and businesses worldwide now use NCS techniques as "offsets," which are arrangements to finance carbon-sequestration projects anywhere in the world

141. *Deepwater Horizon Oil Spill Settlements: Where the Money Went*, NOAA, https://www.noaa.gov/explainers/deepwater-horizon-oil-spill-settlements-where-money-went (Apr. 20, 2017).

142. Joshua Schneyer, *Paint Makers Reach $305 Million, Settlement in California, Ending Marathon Lead Poisoning Lawsuit*, REUTERS (July 17, 2019), https://www.reuters.com/article/us-usa-lead-settlement/paint-makers-reach-305-million-settlement-in-california-ending-marathon-lead-poisoning-lawsuit-idUSKCN1UC26J.

143. *Id.*

144. Mike Carter, *Families Settle for $75 Million in Bellingham Pipeline Explosion*, SEATTLE TIMES (Apr. 10, 2002), https://archive.seattletimes.com/archive/?date=20020410&slug=webolympic10.

145. *See Pipeline Safety Trust History*, PIPELINE SAFETY TR., https://pstrust.org/about/history-of-the-pipeline-safety-trust/ (last visited Mar. 29, 2024).

146. *See* ROMAN KRZNARIC, THE GOOD ANCESTOR 238 (2020) (stating that there is "an absence of institutional mechanisms that give voice to the interests of tomorrow's generations").

to justify continued fossil-fuel pollution at an altogether different location—in other words, a "pay to pollute" approach.[147] The theory is that the forest or farm will draw down and absorb an amount of carbon equivalent to that emitted as part of the offset. Indeed, many scientists and organizations have promoted NCS as a way to meet emissions-reduction goals.[148]

Some programs are voluntary, whereby corporations entice customers into purchasing offsets to justify the carbon emissions embedded in their purchase, as is the case with airline offsets.[149] Other offsets are tied into government pollution programs, wherein a polluter can continue emitting greenhouse gases if it purchases carbon credits from an approved land-sequestration program—these are compliance-based offsets.[150] California, for example, has a "cap-and-trade" program that uses carbon offsets.[151] In either case, the offset justifies further pollution purportedly through drawing down and sequestering carbon dioxide elsewhere. The simple fact is that NCS techniques can be used either to offset further pollution or to clean up legacy pollution in the sky, but not both: the atmosphere does not allow for double-counting. The land processes used to remove carbon are the same for both offsets and drawdowns, but the aim is vastly different. Offsets remain profoundly misguided as a climate strategy and have come under heavy criticism for multiple reasons.[152]

First and most fundamentally, offsets simply make the climate problem worse—legalizing or legitimizing continued pollution—without making any dent in the legacy pollution that continues to destabilize the climate system. By allowing business-as-usual fossil-fuel pollution to continue, offsets

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147. *See, e.g.*, Robin Pomeroy, *Carbon Offsets – How Do They Work, and Who Sets the Rules?*, WORLD ECON. F. (Sept. 2, 2022), https://www.weforum.org/agenda/2022/09/carbon-offsets-radio-davos/ (questioning the dubious premise of some assertions of carbon neutrality through offsets).

148. Griscom et al., *supra* note 24, at 11645–46.

149. *See Mandatory and Voluntary Offset Markets*, CARBON OFFSET GUIDE, https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/mandatory-voluntary-offset-markets/ (last visited Mar. 29, 2024) (explaining voluntary offsets used by industries like air travel, which entice customers to purchase them in the name of reducing carbon emissions).

150. *See Compliance Offset Programs*, CARBON OFFSET GUIDE, https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/compliance-offset-programs/ (last visited Mar. 29, 2024) (defining compliance-based offsets).

151. *See* Lisa Song & James Temple, *Lawmakers Question California Cap and Trade Policies, Citing ProPublica Report*, PROPUBLICA (Aug. 20, 2021), https://www.propublica.org/article/lawmakers-question-california-cap-and-trade-policies-citing-propublica-report (explaining that the California program is under review after receiving enormous criticism for a failed offset policy).

152. *See, e.g.*, Patrick Greenfield, *Rainforest Carbon Credit Schemes Misleading and Ineffective Finds Report*, GUARDIAN (Sept. 15, 2023), https://www.theguardian.com/environment/2023/sep/15/rainforest-carbon-credit-schemes-misleading-and-ineffective-finds-report (referring to the offset schemes that took place in the Amazon Rainforest); Heidi Blake, *The Great Cash-for-Carbon Hustle*, NEW YORKER (Oct. 16, 2023), https://www.newyorker.com/magazine/2023/10/23/the-great-cash-for-carbon-hustle (elaborating on how carbon offset initiatives in their current form are misguided attempts at curtailing carbon emissions).

prolong the necessary transition toward a renewable-energy economy and undermine the rank urgency of decarbonization.[153] Leading climate scientists recently warned that the world has only six years of emissions left in the carbon budget before dangerous temperatures above 1.5 degrees Celsius are essentially locked in.[154]

Second, as a regulatory tool used to justify and legalize carbon pollution, land-based offsets are deeply flawed because they fail to achieve direct-carbon compensation for the ongoing pollution. Unlike *direct emissions offsets* achieved through actual averted pollution—where the pollution allowed in one place can be calibrated to be equal to or less than the pollution avoided in another place—there is no equal and concurrent carbon refund accomplished through land-based processes. The quantification of carbon sequestered from land-based processes is simply too indeterminate.[155] There is also a fundamental mismatch in terms of timing. A source's contributions to atmospheric pollution are immediate and certain, but drawing down the same amount of carbon through land-based measures elsewhere is comparatively quite slow, taking years, decades, or centuries.[156] During this time lag, the buildup of atmospheric carbon dioxide pushes the planet and Humanity closer to irreversible tipping points that could trigger runaway heating.

Third, during that same time lag, terrestrial systems may degrade from the planetary heating already underway, a dynamic that can hinder the effectiveness of certain land-based processes that were relied upon to justify further pollution. Trees may burn, soils may lose the capacity to support microorganisms necessary to sequester carbon, and grasses may perish in drought. While these processes will undermine the effort of sky cleanup as well, the difference, of course, is that offsets send further pollution to the sky. Put differently, even as offsets rely on NCS, they make the NCS strategy more precarious over the long term.

Fourth, the sequestration of additional carbon pollution is not permanent. The soils, trees, and vegetation will slowly release the carbon back into the

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153. *See generally* Christa M. Anderson et al., *Natural Climate Solutions Are Not Enough*, 363 SCIENCE 933, 933–34 (2019), https://www.science.org/doi/10.1126/science.aaw2741 (explaining that natural climate solutions alone are insufficient to avert climate disaster).

154. Chris Smith & Robin Lamboll, *Carbon Budget for 1.5°C Will Run Out in Six Years at Current Emissions Levels, Says New Research*, PHYS.ORG (Oct. 31, 2023), https://phys.org/news/2023-10-carbon-15c-years-current-emissions.html.

155. Quantification is a challenge in sky cleanup strategies as well, as some funders may need to see quantified progress in carbon storage, but the margin of error in this context does not carry the stakes it does in the offset context because land management is not used as a justification to add to the sky's pollution load.

156. *See* Anderson et al., *supra* note 153 ("Every hectare of forest that is cleared generates a carbon debt that requires decades to centuries for repayment."); Baldocchi & Penuelas, *supra* note 40, at 1195 (explaining that carbon sequestration is a slow process).

sky over time. Thus, while regenerative processes form a needed and urgent measure to draw down legacy carbon and sequester it for the next several decades as these processes begin to reclaim Nature's carbon cycle, they do not permanently remove ongoing pollution entering the atmosphere on the tails of offset schemes.

Fifth, the administrative mechanisms of verifying the land-based sequestration and assuring "additionality" (that is, additional carbon sequestered as a result of the measure)[157] remain highly questionable, if they even exist at all.[158] Recent research suggests that some major offset programs have, when actually monitored, failed to yield additional benefits over what would otherwise have occurred.[159] The entire California cap-and-trade regulatory program is widely criticized as resting on a "faulty offset program."[160] A *New Yorker* investigative inquiry into carbon-offset schemes revealed the minimal government oversight, lack of transparency, inflated benefits, unaccounted-for funds, and failed promises that often plague such schemes.[161] Many leading scientists have expressed justifiable skepticism at the use of soil-based measures to offset further carbon-dioxide pollution,[162]

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157. *See Additionality*, CARBON OFFSET GUIDE, https://www.offsetguide.org/high-quality-offsets/additionality (last visited Apr. 29, 2024) (explaining that "additionality" only credits land managers for GHG reductions that would not have occurred in the absence of a carbon market, which complicates the verification process and limits compensation for practices that are actively sequestering carbon).

158. *See* Lisa Song & James Temple, *The Climate Solution Actually Adding Millions of Tons of CO2 into the Atmosphere*, PROPUBLICA (Apr. 29, 2021), https://www.propublica.org/article/the-climate-solution-actually-adding-millions-of-tons-of-co2-into -the-atmosphere (questioning the existence of administrative mechanisms verifying the additionality of carbon sequestration); *see also* Shane R. Coffield et al., *Using Remote Sensing to Quantify the Additional Climate Benefits of California Forest Carbon Offset Projects*, 28 GLOB. CHANGE BIOLOGY 6789, 6790 (2022) (examining additionality from California's cap-and-trade program). Some question whether carbon-offset financing has even implemented the projects it promised. *See* Patrick Greenfield & Nyasha Chingono, *'We Don't Know Where the Money is Going': The 'Carbon Cowboys' Making Millions from Credit Schemes*, GUARDIAN (Mar. 15, 2024), https://www.theguardian.com/environment/2024/mar/15/money-carbon-credits-zimbabwe-conservation-aoe.

159. *See* Coffield et al., *supra* note 158 at 6790 (examining California's cap-and-trade program); Blake, *supra* note 152 ("[I]t is extraordinarily difficult to quantify how much carbon these schemes really save. . . . There are also issues of "leakage": even if the agents of deforestation are driven out of one area, they may cut down trees someplace else. . . . Twenty years after Applied Energy Services funded the Guatemalan tree-planting project, researchers found that it had largely failed.").

160. Jonah Valdez, *Is California's Cap-And-Trade Program Hurting the Environment More than Helping It?*, L.A. TIMES (Mar. 22, 2022), https://www.latimes.com/california/story/2022-03-22/what-has-california-cap-and-trade-accomplished.

161. Blake, *supra* note 152.

162. *SNAPP Team: Managing Soil Organic Carbon*, SCI. FOR NATURE & PEOPLE P'SHIP, https://snappartnership.net/teams/managing-soil-organic-carbon/ (last visited Mar. 29, 2024); *see also* Beverly E. Law et al., *Strategic Forest Reserves Can Protect Biodiversity in the Western United States and Mitigate Climate Change*, COMMC'NS EARTH & ENV'T, Dec. 14, 2021, at 1, 7, https://www.nature.com/articles/s43247-021-00326-0 ("Forest carbon accumulation should not be considered as an offset that allows additional fossil fuels to be burned.").

and some have suggested that these measures simply amount to shameful greenwashing without any net benefit to the planet.[163]

Sixth, justice issues pervade these offset schemes, particularly in areas inhabited by Indigenous people who rely heavily on the lands and resources.[164] The big-money carbon deals all too often transpire without any involvement of the local population and may seriously damage the people's survival resources or their access to them.[165] Displacement and exploitation of Native people mark the methods of some notorious carbon-trading firms, and in the Amazon region, some view the firms as "carbon pirates" that prey on the local Indigenous communities.[166]

And finally, land-based offset schemes will compete with and undermine sky cleanup by monopolizing key lands capable of sequestering carbon dioxide.[167] Dedicating a land parcel to an offset scheme precludes it from being an engine of sky cleanup because its carbon sequestration cannot be double-counted. As previously explained, the cleanup of legacy carbon remains vital to regaining climate stability. Securing meaningful drawdown levels requires total, uncompromised maximization of all ethically available land areas.[168] But offset schemes increasingly lock up huge swaths of forestlands and other ecotypes for the purpose of allowing further pollution. Recently, for example, a firm paid $1.8 billion to put 1.7 million acres of

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163. *See, e.g.*, KIRTANA CHANDRASEKARAN ET AL., FRIENDS OF THE EARTH INT'L, NATURE BASED SOLUTIONS: A WOLF IN SHEEP'S CLOTHING 3 (2021), https://www.foei.org/wp-content/uploads/2021/11/Nature-based-solutions_a-wolf-in-sheeps-clothing.pdf ("[B]eneath the veneer[,] NBS is firmly based in carbon and nature neo-colonialism, discredited market mechanisms and corporate greenwashing. NBS instrumentalizes nature as a so-called solution without defining who created the problem."); Pomeroy, *supra* note 147.

164. *See* India Bourke, *"A Further Act of Colonisation": Why Indigenous Peoples Fear Carbon Offsetting*, NEW STATESMEN, https://www.newstatesman.com/spotlight/sustainability/climate/2021/11/a-further-act-of-colonisation-why-indigenous-peoples-fear-carbon-offsetting (Oct. 24, 2022) (discussing prevalent environmental justice issues embedded in carbon cap-and-trade programs that often exploit Indigenous communities: "Planting new forests requires land, as does flooding valleys for new hydro-power projects. And those already living and using that land fear that scaled-up 'land-grabs' will put the security of their livelihoods and cultures at risk.").

165. *New Analysis Reveals Risks of Investment in Carbon Offsets Without Community Rights*, RTS. & RES. INITIATIVE (Feb. 6, 2021), https://rightsandresources.org/blog/new-analysis-reveals-risks-of-investment-in-carbon-offsets-without-community-rights/.

166. *See* Patrick Greenfield, *The 'Carbon Pirates' Prey on Amazon's Indigenous Communities*, GUARDIAN (Jan. 21, 2023), https://www.theguardian.com/environment/2023/jan/21/amazon-indigenous-communities-carbon-offsetting-pirates-aoe (coining the term "carbon pirates" in reference to firms that exploit Indigenous communities in the Amazon); Patrick Greenfield, *Rainforest Carbon Credit Schemes Misleading and Ineffective Finds Report*, GUARDIAN (Sept. 15, 2023), https://www.theguardian.com/environment/2023/sep/15/rainforest-carbon-credit-schemes-misleading-and-ineffective-finds-report (examining carbon-credit schemes in the Amazon region).

167. *See* Griscom et al., *supra* note 24, at 11646 (estimating the global drawdown potential "constrained by a global land cover scenario with safeguards for meeting increasing human needs for food and fiber").

168. *See* Baldocchi & Penuelas, *supra* note 40, at 1194; *see also* Anderson et al., *supra* note 152, at 933 (explaining the importance of maximizing all ethically available land area).

forest stretched across 17 Eastern states into an offset scheme, effectively removing that forest from the land base that could be dedicated to sky cleanup.[169]

For all of these reasons, a regional Framework must reject any offset application of natural climate solutions. The NCS carbon sequestration accomplished through the regional Framework must be singularly dedicated to sky cleanup.[170] This remains important for another reason: to access a line of funding from the fossil-fuel industry based on its legacy pollution liability for atmospheric NRDs, plaintiff sovereigns must apply any funds gained from successful litigation or settlements to actual sky cleanup, not offsets. In other words, no legal theory of NRDs justifies anything other than restoration of the resource, which offset schemes certainly do not advance.

Despite the foregoing critique, the purely descriptive use of offset terminology to quantify NCS potential may be innocuous as long as sequestration achievements are not tied to a regulatory or market allowance for further emissions. For example, the assertion that NCS techniques can "offset the equivalent of 21% of current net GHG emissions in the United States" may be far more effective as an appeal to policymakers than characterizing NCS potential in terms of metric tons of carbon sequestration. The latter terminology remains meaningless to many if not expressed as a milestone towards an overall goal. Importantly, however, the characterization cannot be taken too far. Increasingly, governments use a "net zero" concept to justify further emissions on the illusory basis that emissions will be drawn down and sequestered through natural climate solutions.[171] As emphasized at the outset, emissions must be entirely phased out, *and* the legacy carbon must be drawn down and sequestered as part of a sky cleanup. The concept of "net zero" ignores the reality that Humanity needs both full decarbonization and legacy-carbon cleanup. A climate-true approach would limit offsets to *direct emissions offsets* from a comparable emissions source, using strategies involving electric vehicles, solar panels, windmills, or other energy and transportation measures.

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169. *See* Ryan Dezember, *Wall Street Firm Makes a $1.8 Billion Bet on Forest Carbon Offsets*, WALL ST. J. (Nov. 2, 2022), https://www.wsj.com/articles/wall-street-firm-makes-a-1-8-billion-bet-on-forest-carbon-offset-11667390624 [https://perma.cc/P9WG-TW23].

170. In theory, markets and regulatory schemes offering offsets could continue to operate if, moving forward, they entirely decoupled the land-based carbon sequestration they offer from future emissions and dedicated their purpose and accounting to legacy carbon cleanup. Climate Liable Parties responsible for atmospheric-carbon cleanup could engage such entities to begin to diminish their cleanup liability. They could not at the same time, however, justify ongoing or future emissions through NCS sequestration.

171. *See* Robert Watt, *Carbon Offsets Offer a Fantasy of Capitalism Without Crises*, CONVERSATION (Mar. 12, 2021), https://theconversation.com/carbon-offsets-offer-a-fantasy-of-capitalism-without-crises-155730; U.S. DEP'T OF STATE, THE LONG-TERM STRATEGY OF THE UNITED STATES: PATHWAYS TO NET-ZERO GREENHOUSE GAS EMISSIONS BY 2050, at 3 (2021), https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf.

Offset markets using NCS have proliferated around the globe, recruiting enormous amounts of land. While this offset movement lacks coherence and overall accountability, it is nevertheless true that offset-market entities remain significant players in international climate policy.[172] Some organizations have pioneered effective ways of reaching out to communities and structuring projects, even where the basis of the carbon-offset market as a climate strategy is fundamentally unsound.[173] While the offset policy outbreak may be facing its twilight due to widespread criticism, market players may devise ways of switching the purpose of future NCS projects to gear them to sky cleanup rather than sky pollution. That initiative would productively steer the expertise and techniques used in the carbon markets toward actual atmospheric recovery.[174]

III. FUNCTION AND COMPONENTS OF REGIONAL FRAMEWORKS FOR ATMOSPHERIC RECOVERY (FARS)

An organizing framework for atmospheric recovery (FAR) across a sovereign bioregion requires several components, each informed by a convergence of scientific, land-management, legal, and leadership expertise. A regional FAR must draw on transdisciplinary teams that can match the needs of tribes, private landowners, industry, and rural communities with the knowledge that guides carbon sequestration. In doing so, the FAR serves multiple functions and overcomes identified barriers to NCS implementation[175]—particularly if it becomes a living, iterative, web-based resource that moves through time with the communities it serves. Section III(A) describes the functions of Regional Frameworks; Section III(B) explores the role of Native leadership and knowledge in this modern paradigm of regional land recovery; and Section III(C) inventories the components of the Regional Frameworks.

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172. *See generally* Robert Watt, *The Fantasy of Carbon Offsetting*, 30 ENV'T POL'Y 1069 (2021) (explaining why carbon offsetting is an illusory solution for carbon emissions); *What Are Carbon Markets and Why Are They Important?*, UNDP (May 18, 2022), https://climatepromise.undp.org/news-and-stories/what-are-carbon-markets-and-why-are-they-important; *see also* Watt, *supra* note 171 (explaining that grave uncertainties exist in the accounting process for carbon offsets).

173. *See, e.g.*, *Carbon Markets: Helping Ranchers Profit While Improving Soil Health*, W. SUSTAINABILITY EXCHANGE, https://westernsustainabilityexchange.org/carbon-markets/ (last visited Mar. 30, 2024) (explaining Western Sustainability Exchange's work with ranchers on carbon sequestration).

174. Some lands presently sequestering for offset purposes could perhaps be rededicated to the drawdown of future emissions under complicated transactional and funding scenarios beyond the scope of this Article.

175. Pathek et al., *supra* note 121, at 108 ("The economic and political feasibility of implementing [NCS measures] is hampered by persistent barriers.").

A. Functions of Regional Frameworks

Regional Frameworks could serve as crucial catalysts for region-wide NCS and ecosystem recovery. They first establish a regional vision for drawdown measures and announce the opportunity to land managers, aiming to jumpstart an epic project. By creating a platform of knowledge, the Frameworks open a forum in which to draw critical input from tribal leadership and Indigenous knowledge, as discussed more in Section III(B). Second, using an implementation blueprint that delves into the actual impediments to NCS adoption, the Frameworks can help actualize and accelerate drawdown. Third, by pairing biodiversity goals with climate-recovery goals, the Frameworks can advance solutions to both crises simultaneously. Fourth, the Frameworks can motivate and propel programs for sequestration that are not tied to offsets, directing land commitments towards atmospheric cleanup rather than promoting further carbon pollution—as offsets invariably do. Fifth, by aggregating NCS efforts, the Frameworks can collect the varied experiential lessons that will evolve on the ground from multiple dispersed, synchronous projects. The Framework is the conceptual hub that draws those efforts together and collects their forms of synergy (biological, economic, cultural, and political) into a forward-moving enterprise. Communications experts can harvest the projects' results and benefits and interpret them back into the Framework, thereby building regional momentum. Projects will inevitably generate costs and mistakes as well, and those can become the platform for adaptive management and innovation. Sixth, the Framework can become a model for other regions worldwide, thereby proliferating the drawdown effort well beyond one region.

Finally, the Framework may open major funding avenues for NCS. One such avenue is through court-awarded atmospheric natural-resource damages from carbon majors who are responsible and potentially liable for the legacy carbon in the atmosphere. If regional sovereigns (tribes, states, and counties) sue carbon majors based on their proportionate liability for pollution,[176] courts can turn to the Framework to award a monetary remedy tied to the region's share of atmospheric cleanup. In other fossil-fuel litigation seeking

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176. Multiple suits against fossil-fuel companies for damages are pending but seek remedies related to adaptation financing. *See* Parenteau & Dernbach, *supra* note 125. The liability of these companies is generally premised on theories of public nuisance. The proportionate contribution of each company to the overall legacy carbon has been established and would be applied in atmospheric NRD litigation. *See* discussion *supra* Section II(A)(2). If a company is responsible for X GtC of legacy carbon in the atmosphere and finances cleanup under the Framework, the carbon removed becomes a subtractable amount from the company's remaining liability. In an open-use legal domain, such company liabilities can be accounted for over time as they diminish, even as they are applied to multiple regional endeavors.

adaptation costs, the Framework can identify NCS measures with adaptation benefits. Other potential sources of funding include government and philanthropic funds, a carbon tax, or new bonds. In many of these contexts, the funding entity or court seeks to know how much carbon sequestration will be accomplished through the funding. A Framework can quantify the projected carbon drawdown correlating to projects or practices that implement the protocols in various sectors. Moreover, these protocols can provide a gold standard for practices that are tailored to the locality and therefore serve a validating function.

B. Seeing the Future with Two Eyes: Incorporating Native Sovereignty and Indigenous Wisdom

At this time of climate emergency and biodiversity crisis, it is hard not to juxtapose the Indigenous management of ecological systems for millennia with the abrupt, relentless eradication of Nature accomplished by the state and federal governments in just two centuries.[177] The insatiable economic model of capitalism and the Western cultural approach of conquering and exploiting land and natural bounty—and then studying the disastrous consequences without actually mustering the political will to reverse ecological losses and recover functioning systems—stands in stark contrast with Native models and cultural approaches that have sustained innumerable human societies on every continent since time immemorial. At this juncture, incorporating tribal wisdom and management structures into the regional enterprise of recovering natural systems to bring the carbon cycle back into balance is imperative. A leading report on Blue Carbon in Canada underscored this need:

> For millennia, Indigenous Peoples have cultivated respectful relationships with their lands and waters. Indigenous Peoples' legal, governance, and knowledge systems have contributed to successful environmental stewardship practices in Canada and around the world. Indeed, these long-standing practices have often shaped the blue carbon ecosystems that scientists, conservationists[,] and governments increasingly wish to manage and protect. Because of

177. *See* Mary Christina Wood, *The Politics of Abundance: Towards a Future of Tribal-State Relations*, 83 OR. L. REV. 1331, 1335 (2004) [hereinafter Wood, *Politics of Abundance*] (comparing, in the context of Columbia River salmon management, the "politics of abundance" as practiced by tribal leaders with the "politics of scarcity" as practiced by federal and state fisheries managers).

> this long-standing expertise that is rooted in place, Indigenous Peoples are well positioned to lead blue carbon conservation.[178]

Indeed, as the Report warns, without the participation of tribal governments or representatives, NCS initiatives risk dispossessing Native people of their lands and resources or limiting their access to vital areas—in essence, spreading "climate colonialism."

Beyond that, Western society desperately needs to learn a holistic and compatible approach to living on the land. The land-recovery imperative is so pervasive and urgent that it cannot be accomplished by adhering to the same legal, social, and economic structures that abused Nature. Perhaps nothing short of a cultural sea change can inspire the necessary ecological recovery worldwide to save Humanity and other species. The eminent Native legal scholar Rennard Strickland once said that "[i]f there is to be a post-Columbian future—a future for any of us—it will be an Indian future . . . a world in which this time, . . . the superior worldview . . . might even hope to compete with, if not triumph over, technology."[179]

Standing alone, NCS initiatives may further commodify the natural world, never getting at the cultural root of the environmental crisis.[180] The ancient teachings of Indigenous communities emphasize the duty to other living creatures as animate beings—relatives—as well as the steadfast duty to future generations.[181] As the Canadian Blue Carbon Report states, "NCS can be enhanced by Indigenous worldviews that emphasize reciprocity and relationships between people and ecosystems. This framing is different from the market-based approaches to climate-change mitigation typical of NCS."[182] The Report notes the distinction between NCS as practiced by non-Native entities and individuals, which often revolves around jurisdictional and economic considerations, with Indigenous-led conservation efforts:

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178. Kelly B. Currie et al., COASTAL BLUE CARBON IN CANADA: STATE OF KNOWLEDGE 23 (2023), https://wwf.ca/wp-content/uploads/2023/06/BlueCarbon_StateofKnowledge_Report.pdf [hereinafter COASTAL BLUE CARBON].

179. Rennard Strickland, *Tonto's Revenge: Reflections on American Indian Culture and Policy*, 23 AM. INDIAN CULTURE & RSCH. J. 130 (1999).

180. For a leading essay contrasting "industrial thinking" with "Indigenous thinking," *see* Winona LaDuke, *Voices from White Earth: Gaa-Waabaabiganikaag* (1993), https://centerforneweconomics.org/publications/voices-from-white-earth-gaa-waabaabiganikaag/ ("Industrial language has changed things from being animate, alive, and having spirit to being inanimate, mere objects, and commodities of society. When things are inanimate, 'man' can view them as his God-given right. He can take them, commodify them, and manipulate them in society.").

181. *See* COASTAL BLUE CARBON, *supra* note 178 ("Blue carbon exists in animate ecosystems in the territories of coastal Indigenous Peoples.").

182. *Id.* at 22; *see also How We Work with Carbon Markets*, THE NATURE CONSERVANCY, https://www.nature.org/en-us/what-we-do/our-priorities/tackle-climate-change/climate-change-stories/carbon-market-credits-offsets/ (last visited Mar. 30, 2024) (explaining the approach for working in carbon markets).

> Indigenous-led conservation offers insight into how to care for blue carbon and coastal ecosystems in ways that honor the interconnections of the land, the sea[,] and the people who live there. [T]he tendency to treat Indigenous knowledge as supplemental to western environmental management approaches can miss the deeper understandings, values[,] and contexts inherent in Indigenous knowledge systems. Missing this bigger picture, proponents of NCS may also miss opportunities to approach blue carbon solutions from a place of collaboration rooted in principles of respect and reciprocity. As Reed *et al.* (2022) suggest, it is essential "not only to advance the self-determination of Indigenous Peoples, but also *to create the ceremonial ground for Indigenous visions of nature-based solutions*."[183]

This ceremonial ground of recovery is missing in Western culture. Promises of ecological recovery remain unrooted in cultural and spiritual imperatives, causing political leaders to indulge powerful business interests at the expense of fellow species and future generations. This perpetuates a Western "politics of scarcity" with respect to resource management.[184] This contrasts with the Native philosophy around resource management described by traditional tribal leaders:

> [T]he trust responsibility towards future generations is heartfelt. Restraint is created not by a written code, but by a culture of reverence towards Nature, reinforced by natural law—a spiritual set of laws—expressed in ceremonies. Ceremonies continually affirm a connection with Nature, with ancestors, and with future generations, and they fortify the *will* to make good on those connections. Tribal elders and leaders go out to the rivers, where they sing and pray for the return of the salmon just as their ancestors did. There is *will* created in that act to preserve this marvelous species, and there is a turning away from indulgence that satisfies only the present generation. Ceremonies engrain the wisdom of self-restraint that keeps guiding leaders towards the politics of abundance. That wisdom shapes the Native art of governance in natural resources law.[185]

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183. COASTAL BLUE CARBON, *supra* note 178, at 24–25 (emphasis added).

184. Wood, *Politics of Abundance*, *supra* note 177, at 1344 ("Every devastated watershed, every new mile of sprawl, and every new clearcut reflects excessive indulgence. This is a very deep failure in government, and its effects will be felt by every citizen living today and tomorrow.").

185. *Id.* at 1345.

The regional NCS endeavor presents a historic opportunity for cultural exchange and infusion of tribal wisdom into Western land-management conversations and decision-making. The possibility is captured by a term coined by Elder Albert Marshall of the Mi'kmaq, an Indigenous First Nations people of Canada. He offers "Two-Eyed Seeing" to invite a "collaborative, integrative approach of 'knowledge creation, mobilization and translation":[186]

> Two-eyed seeing refers to learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of western knowledges and ways of knowing—and learning to use both of these eyes together for the benefit of all.[187]

In some (or perhaps most) regions, strong tribal institutions exist to bring "two-eyed seeing" into NCS opportunities. Many tribal agencies have emerged in response to the need to recover populations of treaty-protected fish and wildlife species decimated by industrialization. By necessity, all these tribal sovereigns and their agencies now engage in climate work and are able to synergize NCS approaches with their other goals to promote species recovery, strengthen cultural practices, and provide for their people. In the Pacific Northwest, for example, the Columbia Inter-Tribal Fish Commission (CRITFC) represents the four major treaty-fishing tribes of the Columbia River Basin and co-leads fish recovery throughout the Basin. For decades, CRITFC has presented a model of regional ecological leadership, devising and promoting an ambitious and visionary region-wide plan to recover the salmon to historical abundance levels, while protecting these tribes' sacred right to fish.[188] In the Puget Sound area, the Northwest Indian Fisheries Commission plays a similar role, as does the Great Lakes Indian Fish and Wildlife Commission in the Northeast and Midwest. On a national level, the National Indian Carbon Coalition was created to develop tribal carbon-sequestration projects.[189]

A Regional Framework for Atmospheric Recovery offers a singular opportunity to bring tribal leadership and perspectives into the collaborative process of envisioning land restoration and carbon sequestration. As a non-

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186. COASTAL BLUE CARBON, *supra* note 178, at 35.

187. *Id.* at 49.

188. Wood, *Politics of Abundance*, *supra* note 177, at 1342.

189. *See Economic Opportunity: Carbon, Climate and Indian Country*, NAT'L INDIAN CARBON COAL., https://www.indiancarbon.org (last visited Mar. 30, 2024) (showing that NICC offers independent information and technical assistance to tribal nations, communities, and individual members to develop carbon projects).

governmental program, the Framework offers a flexible forum for participation from the outset. Each component of the Framework (described below) will benefit from attention to tribal needs, perspectives, values, and opportunities. In particular, to maximize the "two-eyes" management concept, a focus throughout the FAR should be on developing tribal opportunities for co-management outside of the present tribal land base, as well as prospects for funding significant tribal work aimed towards ecological recovery. As the Canadian Blue Carbon report concludes, "[b]lue carbon initiatives are more likely to be just and effective if we support Indigenous-led initiatives and co-develop new initiatives with Indigenous Nations and communities."[190] The next Section delves into the components of regional FARs.

C. Components of Regional FARs

As noted throughout this Article, a Regional Framework builds a conceptual bridge between NCS opportunity and actual implementation. It announces a new form of social enterprise responsive to the urgency presented by the climate emergency and the biodiversity crisis. Accordingly, the Framework must explore the opportunities and barriers to NCS in a very practical way. It must address the challenge as it unfolds, from the initial vision to the landowner buy-in to the implementation of monitoring and durability tools that will ensure lasting carbon sequestration. While Regional Frameworks will naturally differ, several basic components are cataloged below.

It should be noted that decarbonization, while not the focus of this Article, could well be considered a necessary and integral part of a Regional Framework. The reason is plain: without decarbonization, there will be little or no actual *sky cleanup*—just the maintenance of a highly elevated and dangerous level of atmospheric CO_2. Many analogize the atmosphere to an overflowing bathtub: returning manageable water levels requires both stopping the faucet and unplugging the drain.[191] If the carbon sinks increase their productivity (through NCS), the gains will simply be negated by additional carbon added to the atmosphere. But decarbonization, while a necessary part of cleanup, involves its own complex set of policy, funding, and legal initiatives and falls outside the scope of the present Article.

190. COASTAL BLUE CARBON, *supra* note 178, at 25.

191. *Bathtub Model*, CARNEGIE MELLON UNIV., https://www.cmu.edu/gelfand/lgc-educational-media/succeed/climate-environment-lesson-plans/bathtub-model.html (Sept. 22, 2013).

1. Regional Restoration Potential and Regional Climate Injury

A Regional Framework must provide an overview to contextualize the restoration enterprise by (1) depicting the region's relative carbon-sequestration opportunities at a macro-level (i.e., juxtaposed against the global carbon cycle); and (2) inventorying the massive harm the region will suffer due to climate disruption. This overview is generally important for funders, as many may be making choices between various regions to support and will consider not only the opportunity for sky cleanup, but also the gravity of present and future harm. These two categories of information are also important for courts presiding over litigation against Carbon Liable Parties, as explained below.

As to the first category of information, the Framework should bring the sky-cleanup effort to a tangible level that courts and funders will understand. The report must clearly explain the Earth's carbon cycle, identify the "engines" of sky cleanup as land-based methods, and delineate the restoration potential of the particular sovereign or sovereigns. Depending on their ecotypes, regions naturally differ in their capabilities for drawdown. Some regions, like the Pacific Northwest, have ancient forests with massive carbon-sequestering trees, while other regions, like the Great Plains, have sprawling prairie lands. Global maps exist to show the restoration capacity associated with various landscape categories, such as forests, wetlands, mangroves, and agricultural soils.[192] From that global overview, scientists can extrapolate the carbon-drawdown potential for a particular region, identifying the existing carbon sinks that must be protected or restored.

The second category of information—summarizing climate damage to the region—is important not only for funders and the public but also for grounding any lawsuit against Carbon Liable Parties. Courts provide remedies only for tangible "harms," and every lawsuit must detail both the harm and potential remedies for that harm. In a climate lawsuit, the claimed regional harm may be sea-level rise, raging reoccurring wildfires, mega-storms, heat domes, parching drought, or any of the above and more. Whether the lawsuit seeks damages for adaptation or atmospheric natural resource damages, courts may look to the Framework as a credible report to connect this regional harm with natural climate solutions that can simultaneously help abate the climate heating (through carbon sequestration) and protect the human population (through adaptation).

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192. *See, e.g.*, Jonathan Sanderman et al., *A Global Map of Mangrove Forest Soil Carbon at 30m Spatial Resolution*, ENV'T RSCH. LETTERS, Apr. 30, 2018, at 1, 1, https://iopscience.iop.org/article/10.1088/1748-9326/aabe1c ("The resulting map products from this work are intended to serve nations seeking to include mangrove habitats in payment-for-ecosystem services projects and in designing effective mangrove conservation strategies.").

2. Opportunity Mapping

Maps are a tool to inform, connect, empower, and engage. A Regional Framework can capitalize on the power of mapping and data synthesis to specifically target NCS investments. The Framework should develop a spatially explicit "opportunity map" to announce opportunities for participation in drawdown projects. Databases compiling information related to soil types, vegetative cover, land uses, land ownership, and zoning present basic information for assessing opportunity.[193] At a more detailed and interactive level, this format can incorporate specific protocols and pricing, reflecting the Framework components described below.

Beyond the integral base layer dedicated to carbon-sequestration potential, other map layers can signal targets of opportunity for funders to address the biodiversity crisis and advance a range of co-benefits associated with restoration. Maps of fish and wildlife habitat, flood plains, and water courses exist for most regions.[194] As such, the Framework may draw funders who are primarily interested in drinking water-source protection, wolf recovery, or scenic-lands protection, but who wish to simultaneously advance climate recovery because they recognize that climate stability is a necessary predicate to their primary conservation goal.[195] The opportunity map provides a mechanism responsive to a full array of ecological interests and, in that manner, can attract a broader set of funding opportunities. Because the Framework operates regionally, it may invite organizations to make strategic programmatic investments in landscape restoration rather than invest in an assortment of individual, disconnected projects.[196] Maps of

193. *See* Silva et al., *supra* note 75, at 8, Table 2 (providing "examples of available data sources to be harmonized for opportunity mapping").

194. *See, e.g.*, *Flood Maps*, FEMA, https://www.fema.gov/flood-maps (last visited Mar. 30, 2024) (providing flood plain maps); *Forest Atlas of the United States*, U.S. FOREST SERV., https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Forest-Atlas-of-the-United-States.pdf (last visited Mar. 30, 2024) (providing maps of forested areas of the U.S.); *Maps*, USGS, https://www.usgs.gov/mission-areas/water-resources/maps (last visited Mar. 30, 2024) (providing links to maps of watersheds and aquifers in the U.S.); *Download Species Range and Predicted Habitat Data*, USGS, https://www.usgs.gov/tools/download-species-range-and-predicted-habitat-data (last visited Mar. 30, 2024) (providing maps of wildlife habitats).

195. For example, in Oregon, the Oregon Watershed Enhancement Board (OWEB) distributes funds aimed at watershed restoration and enhancement. *See Oregon Watershed Enhancement Board Will Consider Climate in Grantmaking and Launch Inclusive Engagement Effort*, OR. WATERSHED ENHANCEMENT BD. (Feb. 28, 2022), https://content.govdelivery.com/accounts/ORWEB/bulletins/309bf16 ("The resolution also commits the agency to add climate-focused criteria to restoration grant applications. . . ."). OWEB has also gained climate expertise and now advances climate objectives as part of its grant programs. *Id*.

196. Moreover, with full climate recovery in mind, NCS opportunity maps can also show lands needed for solar and wind projects to minimize competition between decarbonization and drawdown goals and to enable complementary approaches on the ground.

ceded aboriginal territory form a crucial part of this component as they underscore tribal interests across the landscape.

3. Operable Blueprint for NCS: The Land Management Protocols

Scientific expertise forms a foundation of the sky-cleanup effort, as carbon-drawdown opportunities must be tied to specific protocols and monitoring parameters. A Regional Framework must synthesize existing science to formulate field protocols that can guide the design and implementation of NCS projects and also serve as eligibility parameters for proposals. In doing so, the "two-eyes" approach is vastly important, as it brings in Indigenous knowledge that provides historical perspective, ground-truthing through generations of observation, and a holistic approach that incorporates human needs and broader ecological objectives. Drawdown protocols reflecting the "best practices" for carbon management in each sector should be written in a form accessible to a broad array of implementers. For example, protocols will address guidelines and criteria around reforestation, nutrient management, silvo-pastoralism, no-till agriculture, improved forest management, estuary restoration, multi-paddock grazing, and cover cropping, to name just a few (in different ecotypes). Some natural climate solutions may remain too uncertain to form a basis for recommended pathways[197] but may be formulated into prescriptions for pilot projects to build the evidence base for future evaluation.[198]

The scientific community has produced generalized strategies to accomplish NCS across the forest, farmland, grassland and rangeland, and blue carbon landscapes.[199] As noted earlier, scientists divide the NCS approach into three types of action: (1) "Avoided Conversion NCS"; (2) "Land Management NCS"; and (3) "Restoration NCS."[200] In an analysis specific to Oregon, a team led by Dr. Rose Graves applied all three approaches and estimated CO_2 sequestration from various pathways within each category.[201] Such work provides an impressive start to a Framework's delineation of specific protocols.

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197. *See, e.g.*, Mark A. Bradford et al., *Soil Carbon Science for Policy and Practice*, 2 NATURE SUSTAINABILITY 1070, 1070–72 (2019) (noting uncertainty).

198. Some analysts note the need to move forward despite uncertainty. *See, e.g.*, COASTAL BLUE CARBON, *supra* note 178, at 26 ("Ensure that current knowledge gaps do not delay action on the ground. No regret actions, such as protected and conserved areas, can meaningfully benefit biodiversity and climate, regardless of the magnitude of the benefit.").

199. *See* Fargione et al., *supra* note 25, at 1 (outlining the NCS methods researchers examined); Griscom et al., *supra* note 24, at 11645–46 (providing a table and discourse analyzing the climate mitigation potentials of these NCS practices).

200. *See* Graves et al., *supra* note 48 (explaining each type of action); *see also* Silva et al., *supra* note 75 (generalizing different types of NCS).

201. Graves et al., *supra* note 48, at 6.

The "Avoided Conversion" category generally involves conserving and protecting existing carbon sinks. This is vastly important because vulnerable ecosystems contain (on a global level) at least 260 Gt of "irrecoverable carbon" that intrusive land-use practices could release into the atmosphere.[202] Nevertheless, this category is inherently murky because conservation measures largely boil down to legal mechanisms to protect a carbon sink. For example, to protect a forest sink that remains in private ownership, a project manager would devise a conservation easement or other legal instrument to restrict harvest or clearcutting and subsequent conversion to urban development in legal perpetuity. But in Oregon, where land-use measures strictly prohibit much conversion of forest land to urban land, NCS measures preventing urban development may not result in much "additionality," though measures restricting clearcutting on private lands outside riparian buffers certainly could, in light of Oregon's notoriously lax forest-protection laws.[203] In other words, to count carbon sequestration resulting from conservation measures, one must explore whether the land-conservation protocol adds protection (additionality)—an analysis that is primarily legal, not scientific, in nature. Nevertheless, with that caveat in mind, the category of "Avoided Conversion NCS" in Oregon includes (for various ecotypes): (1) preventing forests from succumbing to urban development; (2) protecting sagebrush steppe from invasive annual grasses, which typically encroach because of fire disturbance; and (3) preventing carbon-rich grasslands from becoming cropland.[204]

The remaining two NCS categories contemplate positive human intervention to rebuild depleted carbon pools.[205] Within the "Land Management NCS" category, the team identified, *inter alia*: (1) timber-harvest deferral; (2) use of cover crops in farming; (3) adoption of no-till agriculture; and (4) adjusting cropland-nutrient management to decrease nitrogen fertilizer.[206] Within the "Restoration NCS" category, the team identified, *inter alia*: (1) reforestation after wildfires; (2) tidal-wetland restoration; (3) riparian reforestation; and (4) sagebrush-steppe restoration.[207]

Many protocols and data sets from which future protocols could be developed already exist but require further extrapolation tailored to the particular region. For example, the USDA's Natural Resource Conservation

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202. Silva et al., *supra* note 77, at 7 (citing Allie Goldstein et al., *Protecting Irrecoverable Carbon in Earth's Ecosystems*, 10 NATURE CLIMATE CHANGE 287 (2020)).

203. *See* Wood, *The Oregon Forest Trust*, *supra* note 51, at Part II (discussing Oregon forest management policies and laws prioritizing timber harvest).

204. Graves et al., *supra* note 48, at 3–7.

205. *See* Bossio et al., *supra* note 46 ("25% of natural carbon capture gains depend on rebuilding carbon pools.").

206. Graves et al., *supra* note 48, at 7–10.

207. *Id.* at 10–12.

Service offers very general protocols for farmers and ranchers to store carbon.[208] Additionally, leading scientists have specified general forest management protocols to store carbon.[209] Building on this platform, the next basic step requires translating these identified pathways into a level of specificity necessary for actual implementation across recruited working lands in the particular region. For example, while the use of cover crops is a suggested NCS pathway for farmland carbon sequestration, specific protocols address precise plant species suitable for use, timeframes for planting, tending needs, and so forth—the kind of detail a land manager needs for implementation. Similarly, the NCS pathway for wetlands restoration must identify specific restoration protocols according to soil type and geographic location, and restoring sagebrush-steppe systems requires protocols describing characteristics of suitable land (e.g., concerning elevation and moisture gradients).[210] Moreover, each protocol must be accompanied by an individualized monitoring mechanism, which is detailed in Section III(C)(8) below. Ultimately, the Framework should synthesize and evaluate existing science to develop a detailed set of protocols for each NCS pathway.

One area that warrants further examination is the urban role in carbon drawdown and sequestration. Although typically lacking the vast consolidated acreage of rural landscapes, urban areas nonetheless can aggregate smaller plots that collectively may provide meaningful carbon sequestration. Moreover, urban areas might supply key elements necessary for some of the other pathways—such as urban compost used in carbon farming[211]—or may pose key threats to other pathways, such as urban encroachment on grassland or farmland. Urban drawdown may also yield socio-economic and justice co-benefits, such as increased climate resiliency through efforts like tree planting, which provides shade canopies in heat waves. And on an entirely different level, educating the urban populations and recruiting them into the regional vision of sky cleanup may help bridge the notable urban-rural divide and enlist a region's power centers in support of the atmospheric-drawdown and biodiversity-recovery effort.[212]

As to all of the protocols across the four sectors, adaptive change is key to the success of any regional atmospheric-recovery effort. As new pathways

208. *NRCS Climate-Smart Mitigation Activities*, U.S. DEP'T OF AGRIC., https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/climatechange/?cid=nrcseprd1881023#soil (last visited Mar. 31, 2024).

209. *See* Law et al., *Land Use Strategies*, *supra* note 51, at 3663 (listing established methods of storing carbon through forest management).

210. *See* Graves et al., *supra* note 48, at 12.

211. *See Compost*, MARIN CARBON PROJECT, https://marincarbonproject.org/compost/ (last visited Mar. 31, 2024) (explaining the role of compost in carbon farming).

212. Silva et al., *supra* note 75, at 9 ("A new paradigm of collective action is needed to devise synergistic urban and rural strategies toward shared goals.").

draw scientific inquiry, and as science reveals success or failure from existing pathways, updated information must adroitly enter the Framework. An essential function of the Framework, therefore, is not only to delineate practices with the precision needed to guide land managers, but also to provide the apparatus to amend protocols in a rapidly changing world. In other words, the Framework itself must be flexible and aim towards regular revision.

One example of emerging NCS science involves the well-established NCS pathway of no-till agriculture. Because tilling the soil releases soil carbon into the atmosphere, it was long thought that no-till practices could sequester significant carbon across farmlands.[213] That assumption has come into question as a result of more recent science.[214] Namely, while the Graves team included no-till agriculture as one of the drawdown pathways available in Oregon, it also noted that "no consensus exists on the effects of no-till on SOC (soil organic carbon) in the PNW" and that at least two studies found "no significant effect of tillage on SOC."[215] Whether or not the practice is useful in the PNW region or in other regions, this serves as an example of the need to regularly modify the Framework as science emerges based on the data collected from existing projects. Another area of rapidly developing NCS science that has the potential to open new pathways for sequestration explores accelerated-weathering techniques, which could be combined with agricultural soil amendments described above.[216]

4. Biodiversity Analysis and Assessment of Ecological Co-Benefits and Drawbacks

As noted at the outset, the converging crises of climate instability and biodiversity impoverishment require an urgent and coordinated response. The two cannot be addressed separately because protocols for carbon

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213. *See* Stephen M. Ogle et al., *No-Till Management Impacts on Crop Productivity, Carbon Input and Soil Carbon Sequestration*, 149 AGRIC., ECOSYSTEMS & ENV'T 37, 37 (2012) (explaining that "many publications and reports during the last two decades have recommended no-till as a practice to mitigate greenhouse gas emissions through soil [carbon] sequestration").

214. *Id.* ("The efficacy of no-till agriculture for increasing [carbon] in soils has been questioned in recent studies.").

215. Graves et al., *supra* note 48, at 9; *see also* William R. Horwath & Yakov Kuzyakov, *Chapter 3: The Potential for Soils to Mitigate Climate Change Through Carbon Sequestration*, 35 DEV. SOIL SCI. 61, 66 (2018), https://www.sciencedirect.com/science/article/abs/pii/B978044463865600003X ("[O]f more than 100 studies, about half reported SOC sequestration rates greater in tilled than no-tilled systems."). Horwath and Kuzyakov conclude that "no-till systems have limited potential for climate change mitigation due to limited SOC sequestration." *Id.* at 67. For additional analysis, *see* KATE LAJTHA ET AL., *The Second State of the Carbon Cycle Report*, 469–506 (Cavallaro et al. eds., 2018), https://doi.org/10.7930/SOCCR2.2018.Ch12.

216. *See supra* text accompanying note 76 (explaining the role of geologic carbon storage in NCS methods).

sequestration, if not designed with biodiversity in mind, may further exacerbate biodiversity loss.[217] For example, planting monoculture tree farms for the purpose of seizing sky carbon comes at the expense of biodiversity, which requires a far more complex ecological arrangement to thrive.[218] One component of the Framework must analyze the effect of the protocols on biodiversity. This analysis is increasingly becoming standard practice in developing NCS, and some use the biodiversity screen to roundly eliminate otherwise promising carbon-directed protocols.[219]

Other pressing ecological needs of society—for example, clean drinking water, a stable food supply, and flood protection—also require attention. Beyond the opportunity map described above that depicts various ecological values, a Framework should provide information and analysis linking particular protocols to an array of expected co-benefits. For example, regenerative-agriculture protocols sometimes eliminate pesticides, herbicides, and other chemical applications in the production of crops so as to encourage thriving soil-microbial systems that process and sequester carbon. This measure can boost food production by enriching the soil, and it also reduces toxic water pollution which harms humans, fish, and wildlife.[220] Protecting coastal wetlands may provide a buffer to storms, create habitat for fish and wildlife, and offer recreational opportunities for the community.

Some studies have indicated that co-benefits may, in some circumstances, be the driving force behind the adoption of NCS protocols, possibly even more so than direct economic benefits like funding. One analysis that synthesized previous studies related to farmers' positions on soil-carbon sequestration revealed that co-benefits such as soil fertility, reduced erosion risk, and water-holding capacity were often more important to farmers than financial incentives.[221] Because land managers may reap benefits far beyond monetary compensation alone, it is critical to identify and evaluate these co-benefits so they can be fully leveraged for NCS adoption.

The Framework's examination of co-benefits will allow land managers and funders to form partnerships along a multitude of parameters beyond carbon sequestration. But at the same time, the Framework must also encompass a rigorous inquiry exposing ecological drawbacks and uncertainties associated with certain protocols. For example, techniques of

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217. Law, *Creating Strategic Reserves*, *supra* note 11, at 722 ("[F]unctionally separating carbon, water, and biodiversity and considering them independently leads to actions that inadvertently reduce the values of each, and can increase caron emissions.").

218. Steffan Messenger, *Climate Change: Corporate Mass Tree Planting Damaging Nature*, BBC (Nov. 9, 2021), https://www.bbc.com/news/uk-wales-59220669.

219. Graves et al., *supra* note 48, at 3.

220. SCI. FOR NATURE & PEOPLE P'SHIP, *supra* note 162.

221. Holly Jean Buck & Alexis Palumbo-Compton, *Soil Carbon Sequestration as a Climate Strategy: What Do Farmers Think?*, 161 BIOGEOCHEMISTRY 59, 62 (2022).

intensive grazing, while seemingly offering promise in certain contexts, may impose substantial harm if the grazing occurs near riparian areas.[222] Or, if not near riparian areas, they may require new water-delivery systems carrying an additional ecological footprint. In sum, the Framework must strive for an unvarnished assessment of the ecological trade-offs and risks associated with the protocols in addition to an evaluation of the potential co-benefits.

5. Justice, Socioeconomic, and Community Needs and Opportunities

NCS approaches should draw forth core justice inquiries and analysis of equity issues, particularly when choices arise as to allocating the benefits of restoration investment or imposing a negative burden on communities. It is critical to involve community interests when devising solutions and allocating program benefits. Importantly, the process must consider all community interests—not just those of the resource users and land managers—with concerted outreach to Indigenous communities, communities of color, historically impoverished communities, children, and marginalized peoples who could be affected. For too long, those communities have suffered harm related to hazardous pollutants and resource degradation and may benefit from landscape recovery. But also, a transition from an extractive economy to regenerative and sustainable practices must be a *just transition*, considering the vital need for economic stability in resource-dependent communities. Finally, a core justice requirement centers on the role of youth in devising a vision for landscape recovery, as youth and future generations will inherit the responsibility of a drawdown project—and will either bear the consequences of failure or reap the benefits of its success.

Opportunity assessment requires weighing the benefits and drawbacks of restoration on social, economic, and cultural scales. Such an approach responds to the UN Intergovernmental Panel on Climate Change's (IPCC) call for land-based measures to be informed by "more realistic assessments that take into account local circumstances and socio-economic factors and cross-sector synergies and tradeoffs. . . ."[223] Many questions concerning potential drawbacks exist. For example, will the conversion of agricultural land to forest shrink the available land base necessary for a local food supply? Will forest protection compromise timber supply to local mills and result in economic dislocation and, if so, are there mitigating courses of action, such as sourcing alternative supplies? Will forest conservation preclude using

222. *See generally* AM. FISHERIES SOC'Y, AFS POLICY STATEMENT #23: THE EFFECTS OF LIVESTOCK GRAZING ON RIPARIAN AND STREAM ECOSYSTEMS (2015), https://fisheries.org/wp-content/uploads/2015/05/policy_23f.pdf (outlining the many ways that grazing can impact aquatic and riparian ecosystems).

223. *IPCC Working Group III: Technical Summary*, *supra* note 121, at 88.

wood products as a substitute for carbon-intense steel and concrete in construction and, if so, are there alternative products on the horizon?[224] Re-engineering human systems requires forthright exploration of these drawbacks. Embedded in the Framework, therefore, must be justice-oriented criteria for ensuring protection of human rights, access to food, observance of Indigenous land rights, and respect for cultural prerogatives.[225]

Conversely, as to social, economic, and cultural benefits, some projects and protocols may greatly augment the community's ability to adapt to climate disruption while also boosting the community's economy and strengthening its self-sufficiency. Some protocols may provide job opportunities in an emerging restoration economy. Some protocols may help protect the open space so integral to rural culture. Other protocols may provide opportunities for important tribal practices, such as cultural burning or root-gathering. Some may be the basis of job creation on reservations. By exploring and weighing these favorable aspects, this part of the Framework can generate substantial positive interest on the part of these communities.

In sum, the Framework's vision requires its designers to scrutinize protocols in terms of justice safeguards, biodiversity protection, and societal co-benefits and drawbacks. Nevertheless, a guiding principle must be that difficult dilemmas remain inevitable and are not for the Framework itself to solve. A Framework analysis operates on the regional scale, and localized actuation initiates its own procedural pathway that is necessarily unique to each context. Where the Framework's regional analysis ends, a site-specific implementation discussion begins.

6. Pricing and Funding NCS Projects

Ecosystem protection and regeneration do not typically happen free of charge on working lands. Cost is a driving factor for regional NCS implementation, so it must be assessed. Moreover, determining

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224. *See* Daniel Strain, *Building Materials Come Alive with Help from Bacteria*, CU BOULDER TODAY (Jan. 15, 2020), https://www.colorado.edu/today/2020/01/15/building-materials-come-alive (reporting on alternative building materials).

225. *See, e.g.*, Fargione et al., *supra* note 25, at 1–4 (constraining carbon-sequestration estimates to be compatible with human needs and addressing co-benefits such as crop resilience, coastal defense from storms, and wildfire harm mitigation). A University of Oregon team called this strategy an *Enhanced Natural Climate Solutions* ("NCS+") approach, defining NCS+ as "activities that can be coordinated to increase carbon drawdown and permanence on land while improving livelihoods and the provision of natural resources in vulnerable communities and ecosystems." Silva et al., *supra* note 75, at 1. The team explains that "[t]he framework builds on interdisciplinary scientific convergence, including critical socioecological interactions, to inform both top-down policy incentives and bottom-up adoption by industries and managers." *Id.*; *see also* Lucas C.R. Silva & Mary Christina Wood, National Science Foundation (NSF), *Landscape Carbon Sequestration for Atmospheric Recovery White Paper: A Perspective on Convergence to Accelerate Carbon Sequestration*, University of Oregon, Eugene, Oregon (2019) (hereinafter Silva & Wood, NSF White Paper).

"additionality" is a key part of any project pricing and not a straightforward exercise. The Regional Framework harnesses the expertise of rural economists, land managers, transactional lawyers, and landscape architects to devise a general price structure for the Framework's protocols and additionality standards. This structure will guide opportunity probes by landowners and investment searches by funders, but these NCS protocol price tags will vary according to the circumstances.[226] For example, a farmer implementing cover crops as an NCS measure across a large, dry area will have different costs than a farmer taking the same action across a small, moist area. A landowner establishing a conservation easement on a wetland near a high-development urban area may receive a different price than a landowner pursuing a conservation easement on the same-sized acreage located in a rural corner of the state.

Different NCS approaches—avoided conversion, land management, and restoration—involve different kinds of pricing analysis. Many of the protocols in the second and third categories involve active human intervention, requiring labor, tools, equipment, and other supplies, such as seeds or saplings. Inducing land managers to engage in NCS requires quantifying these costs as well as lost opportunity costs; conversely, on the other side of the ledger, pricing should account for expected monetary benefits associated with the change. Almost always, a landowner will need a "risk buffer" to induce change in management. If a farmer adopts an NCS technique but suffers declined crop yield, a risk buffer would offset the financial loss for a specified period of time.

One cost inherent in all three categories involves dedicating the land to a regenerative purpose to ensure the durability of the action. For example, farming techniques that store carbon must generally persist, or the carbon stored will be lost back to the atmosphere upon cessation of the technique. Because trees lose significant carbon upon cutting, carbon forestry relies primarily on forest conservation. Thus, some NCS methods require a legal instrument—usually a conservation easement or deed restriction—to assure durability of the action. By limiting what the landowner can justifiably do, that legal instrument will likely carry a price tag. Here, the cost analysis differs between public and private lands. Dedicating public land to conservation does not entail this kind of up-front cost, as these lands are owned (in the United States) by the American people and generally reserved

226. It should be noted that the pricing of NCS protocols has no relation to another common climate parameter, the social cost of carbon. Whereas the social cost of carbon is a market tool to assign a price for the harm caused by the carbon pollution, *see* Elijah Asdourian & David Wessel, *What Is the Social Cost of Carbon?*, BROOKINGS INST. (Mar. 14, 2023), https://www.brookings.edu/articles/what-is-the-social-cost-of-carbon/, the protocols represent the cost of atmospheric recovery measures.

from the same market forces that constrain private lands.[227] But price plays a significant role in decision-making about private-land conservation across ecotypes. If an owner seeks to impose a conservation easement protecting existing grassland from conversion to cropland (an "avoided conversion NCS"), the conservation easement will be priced out, and the landowner will either require payment or decide to gain tax benefits through a charitable contribution—regardless, it will be monetized. If a timberland owner is paid to extend harvest rotations from the standard 40 years to 120 years (a "land management NCS"), for example,[228] the 80-year interim dedication to carbon sequestration requires monetary assessment. If an owner of wetlands or farmland agrees to put a carbon conservation easement or covenant across the property, that must be priced out, and so forth.

It would be a gross oversimplification, however, to price these restraints assuming a free-for-all world of landowner prerogative. The pricing analysis must go hand in hand with an evaluation of the legal context because it represents a purchase of activity in which the landowner could otherwise engage. In reality, landowners face a host of regulatory restraints on activities affecting crucial ecology, which invariably tighten as ecology edges ever closer towards collapse—a situation we now face on a global level. For example, grazing in riparian areas, chemical spraying in industrial forests, land-use development, and an array of other activities have encountered increasingly stringent restrictions over the years.[229] One obvious area of more rigid regulation, for example, will be industrial-forest management, which entails clearcutting practices that have harmed local water supplies, unraveled habitat, and emitted carbon during the harvesting process. The regulatory context will inevitably tighten as public pressure mounts to ban clearcutting on private lands, extend harvest rotations, and hold timber companies responsible for damage to water supplies.

The price of conservation measures calibrates to this fluctuating regulatory context. Prices will decrease as regulatory restrictions increasingly constrain harmful activities on private land because, theoretically, the landowner no longer has the right to engage in these activities due to the new regulatory limits. The price of conservation will theoretically never reach zero, however, because conservation easements or

227. As such, public lands can be put to conservation use by public trustees acting to safeguard the public's ecological endowment. President Biden, for example, has announced a proposal to protect old-growth forests from logging as a climate measure. *See* Anna Phillips, *Biden Moves to Ban Most Old-Growth Logging in National Forests*, WASH. POST (Dec. 20, 2023), https://www.washingtonpost.com/climate-environment/2023/12/19/old-growth-logging-forest-service/.

228. *See* Anderson, *supra* note 58 (explaining the implementation of longer timber-harvest rotations as a carbon-sequestration measure).

229. *See, e.g.*, 36 C.F.R. § 219.8(a)(3) (2024) (giving special protection for riparian areas included in land-management plans under federal regulations); OR. REV. STAT. § 527.672 (2024) (limiting aerial herbicide applications in forest operations under Oregon law).

covenants transfer durable property rights in the subject land and carry their own monetized value. Thus, these conservation tools endure changing regulations and thereby hedge against regulatory relaxation.[230] The overall point is that, when considering the price of conservation measures, the analysis must involve a convergence of market and legal expertise.

Taking a macro approach, the pricing section will monetize—in a very general way—the aggregate potential for implementing the regional Framework. Such analysis, while inevitably subject to change, will present an idea of the scale of funding needed—not unlike a cost estimate for Pacific Northwest salmon recovery, wolf reintroduction to the Northern Rockies, or cleanup of a massive oil spill.[231] Such summary economic analysis can include price estimates for benefits to the region as well, an approach taken by the PNW salmon-recovery program.[232] The umbrella cost of materializing a region's atmospheric potential can serve as a guidepost for funders seeking to make large investments in climate recovery.

Key to this part of the Framework is also a compilation of funding sources. A vast number of funding streams that could potentially support NCS actions already exist at the state, federal, and local levels, and more are being developed as a result of new legislation and initiatives.[233] For example, a substantial amount of federal funding is available through the Inflation Reduction Act and could be leveraged for projects implementing NCS. Through this Act, $2.8 billion is available for Environmental and Climate Justice Block Grants, which may be used for climate-resilience and

230. In Oregon, land use restrictions generally forbid residential development outside urban areas. A landowner, however, can still enter into a conservation easement with a land trust and receive value for relinquishing the right to develop land. The price for such an easement will not be as high as in an area where development is allowed, because theory holds that the landowner is not giving up as much if they do not have the regulatory right to engage in the activity. There is nevertheless monetary value in that easement because it is a transfer of a property right to the land trust designed to last in perpetuity. Because regulations do change, sometimes becoming less stringent, the conservation easement serves as ecological insurance against that contingency, and the land trust gains an actual property right in the land to enforce it. So, in theory, conservation easements are never devoid of market value.

231. *See* NAT'L OCEANIC & ATMOSPHERIC ADMIN., PACIFIC COASTAL SALMON RECOVERY FUND: FY 2020 REPORT TO CONGRESS (2020), https://media.fisheries.noaa.gov/2021-07/pcsrf-fy-2020-annual-report.pdf?VersionId=null [hereinafter *Pacific Coastal Salmon Recovery Fund*] (explaining how the Pacific Coastal Salmon Recovery Fund disburses funds to states, tribes, and individuals for salmon-restoration projects); *see* U.S. FISH & WILDLIFE SERV., NORTHERN ROCKY MOUNTAIN WOLF RECOVERY PLAN (1987), https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1018&context=wolfrecovery.

232. *Pacific Coastal Salmon Recovery Fund*, *supra* note 231.

233. *See, e.g.*, Graves et al., *supra* note 48, at 11. Programs proliferate on the state level. For example, in Oregon, the Oregon Watershed Enhancement Board (OWEB) has funds for riparian restoration projects that can implement the NCS blue carbon pathway of riparian restoration. The Oregon Conservation Reserve Enhancement Program (CREP) provides funds for practices on agricultural lands. While beyond the scope of this Article, numerous federal programs already exist, and new ones are coming online as a result of the recently passed Inflation Reduction Act of 2022. *See* Chris Chyung et al., *How States and Cities Can Benefit from Climate Investments in the Inflation Reduction Act*, CTR. FOR AM. PROGRESS (Aug. 25, 2022), https://www.americanprogress.org/article/how-states-and-cities-can-benefit-from-climate-investments-in-the-inflation-reduction-act/.

adaptation projects; $2.6 billion is available through the National Oceanic and Atmospheric Association for climate-resilience projects in coastal areas to conserve and restore habitat and allow communities to prepare for the climate crisis; and $1.5 billion is available through the USDA to support tree-planting activities by local governments, tribes, states, and non-profit organizations through the Urban and Community Forestry Assistance Program.[234]

Though numerous, these funding sources are not yet compiled in a clearinghouse style that would promote scaled-up adoption across landscapes. Moreover, the requirements of these grants are all singularly tied to their unique program purpose, yielding a complicated maze of financial hoops and cumbersome application requirements that may limit uptake in working-lands sectors. The Framework can organize and distill these in a manner designed to streamline the flow of money towards NCS, make recommendations for bundling where appropriate, and develop a role for the Sky Trust in aggregating and facilitating funding sources for large landscape projects where possible.

7. Investment Portfolio: Data-Driven Investment

Each category of NCS entails different payoffs, drawbacks, and uncertainties. Each carries a degree of risk as to whether it will succeed and its anticipated level of permanence. For example, accelerated weathering may have enormous impact,[235] but it is the least studied of the natural climate solutions and therefore carries significant risk. Forests carry a different kind of risk. Their sequestration potential is well established, but they could succumb to fire and lose some of their stored carbon; the risk depends partly on whether the forests are in low- or high-probability fire zones. On the low-risk side, carbon-farming agricultural practices remain well established and have high permanence if durability instruments are applied, but they may not offer as much sequestration potential as other methods.[236]

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234. *See* Amy Turner, *Cities & The Inflation Reduction Act*, COLUMBIA L. SCH.: SABIN CTR. FOR CLIMATE CHANGE L. (Aug. 22, 2022), https://blogs.law.columbia.edu/climatechange/2022/08/22/cities-the-inflation-reduction-act/ (explaining Inflation Reduction Act federal funding for projects implementing NCS).

235. *See IPCC Working Group III: Technical Summary*, *supra* note 121, at 94 (enhanced weathering may have potential to draw down nearly 100 GtC globally, which far exceeds any other category and theoretically comprises nearly two-thirds of the drawdown presently needed); Silva et al., *supra* note 75, at 11–12.

236. *See generally* T. J. Mattila et al., *How Farmers Approach Soil Carbon Sequestration? Lessons Learned from 105 Carbon-Farming Plans*, 215 SOIL & TILLAGE RSCH. (2022), https://www.sciencedirect.com/science/article/pii/S0167198721002774; *see also* Janet Ranganathan et al., *Regenerative Agriculture: Good for Soil Health, but Limited Potential to Mitigate Climate Change*, WORLD RES. INST. (2020), https://www.wri.org/insights/regenerative-agriculture-good-soil-health-limited-potential-mitigate-climate-change.

The Framework should create a generalized carbon-stock investment portfolio depicting risk-yield assessments of NCS sectors and pathways calibrated to the general pricing described above. It can also depict added value for investments in the form of co-benefits. This carbon portfolio must aim to: (1) inform private and philanthropic investment; (2) provide direction to a Sky Trust dispersing court-ordered funds; and (3) create guidance for investment through public bonds, tax programs, grants, and subsidies. The portfolio will also highlight the need for additional funding of NCS science to increase the certainty associated with practices that are high-potential but also high-risk. Just as financial stock positions migrate on the spectrum of risk and yield, the carbon portfolio will change over time as science develops to show the benefits and drawbacks of various strategies. Using the map, portfolio, protocols, and pricing details together, investors and implementers can maximize sequestration and co-benefits while striving to minimize the cost, risk, and uncertainty of various approaches.

8. Monitoring Mechanisms

The success of the Framework rests on wide adoption of the protocols as well as their correct implementation and durability. Essential to the drawdown effort, carefully crafted monitoring mechanisms must assess the effectiveness of each protocol in relation to its stated purpose. Monitoring for carbon drawdown and sequestration can be assessed generally through interval measurements of soil and forest carbon.[237] Quantifying such carbon will indicate trends of sequestration or loss. Depending on the project, other monitoring may evaluate success or failure in achieving co-benefits. Species presence, water-quality characteristics, and ambient-air temperatures, for example, may all be subject to monitoring, as envisioned in the project purpose. Such monitoring procedures must be tightly woven into project contracts and agreements as administered by the Sky Trust (or local partners). In a crisis-laden world that needs rapid adaptive management to respond to emerging science and changing ecological conditions, monitoring results should feed directly into a broader system of regional information analysis and drive adjustments to the Framework and implementing programs.

237. *See* Erin Berryman et al., *Soil Carbon*, FOREST AND RANGELAND SOILS OF THE UNITED STATES UNDER CHANGING CONDITIONS: A COMPREHENSIVE SCIENCE SYNTHESIS 13 (2020); Raisa Mäkipää et al., *How Does Management Affect Soil C Sequestration and Greenhouse Gas Fluzed in Boreal and Temperate Forests? - A Review*, FOREST ECOLOGY & MGMT., Feb. 2023, at 1, https://doi.org/10.1016/j.foreco.2022.120637 (explaining how carbon drawdown and sequestration can be assessed through interval measurements of soil and forest carbon).

9. Technology and Workforce Training

Technology remains key to implementing a region-wide restoration effort and operates on at least two levels. First, technology can enable or facilitate some science-based practices. For example, farmers implementing regenerative-agriculture practices can rely on apps on hand-held devices to calibrate the protocols to site-specific circumstances.[238] Other protocols may require new mechanical technology. Second, technology is vital for monitoring the carbon sequestered in trees and soils and for measuring other parameters of ecosystem recovery.[239] In either respect, the ideal technology may not presently exist.

The Framework should identify how technology can optimize regional deployment of NCS on multiple scales. This alone will broadcast the need to innovators and may spur research-and-development partnerships that would otherwise lag. As new technologies develop, the Framework may incorporate them.

Integrating new NCS land-management methods across forests, farms, grasslands, and wetland areas and then monitoring and reporting the results requires a sweeping workforce-training effort. The Framework will identify areas of skills development, new professional pathways, and partners in the training endeavor. Some organizations situated to carry forth the occupational-training component are the extension services associated with state universities, as well as community colleges, tribal programs, Future Farmers of America, and 4H clubs.

New expertise will also prove necessary to carry out adaptive revision of Framework components—particularly the protocols—as monitoring shows their success and failures, and as worsening climate conditions force re-evaluation. Interdisciplinary degree programs may emerge in the region's flagship universities to meet this need. These programs could include components of landscape architecture, soil science, forestry, planning, business, economics, humanities, communications, law, ecological engineering, data management, and others. On the project level, the NCS effort will require a new type of environmental professional who can serve as a leader of individual carbon-sequestration projects, designing and

238. The U.S. Department of Agriculture's Natural Resources Conservation Service has developed such a tool, COMET-FARM, for general use. COMET-FARM allows landowners to enter details on their land and management such as location, soil characteristics, land uses, tillage practices, and nutrient use through a secure online interface. The tool then estimates carbon sequestration associated with conservation practices for cropland, pasture, rangeland, and livestock operations. *See* SPENCER MILLER, *COMET-FarmTM: Conservation Calculation*, U.S. DEP'T OF AGRIC. (Aug. 21, 2013), https://www.usda.gov/media/blog/2013/08/21/comet-farmtm-conservation-calculation.

239. *See Pathfinder Tool*, CLIMATE POSITIVE DESIGN, https://climatepositivedesign.com/pathfinder/?utm_medium=website&utm_source=archdaily.com (last visited Mar. 31, 2024) (discussing a first-generation app with a focus on sequestration potential).

organizing them from conception to completion. Potentially, NCS project leaders carrying out programs funded through the Sky Trust would (in collaboration with relevant professionals) design the project protocols, price the projects, arrange funding, negotiate with land managers, craft the durability mechanisms, create monitoring systems, and supervise and report results over time. The field of landscape architecture may be particularly poised to gain this new professional proficiency.[240]

10. Durability: The Carbon Storage Easements and Responsive Revision

Part of the implementation challenge will be to create legal mechanisms that provide durability to the carbon-storage enterprise. These instruments must anticipate and compel necessary revisions in NCS practices as a result of monitoring. One important tool to accomplish these ends is a new form of conservation easement called a "carbon storage easement."[241]

A conservation easement is a widely used tool in land- and water-conservation efforts. It essentially amounts to a property right voluntarily conveyed by a property owner to a land trust, tribe, or government entity for the purpose of protecting values or resources on the property.[242] These resources could be scenic vistas, open spaces, fish or wildlife habitats, cultural resources, or a host of others. Generally, the landowner retains ownership of the property and nearly all of the privileges of ownership but relinquishes the right to harm or destroy the resources.[243] The restrictions are always a matter of negotiation between the receiving entity and the landowner; thus, easements vary greatly. Working-lands easements allow the landowner to continue deriving economic benefits from the enterprise but within limits arrived at through mutual agreement. Carbon-storage easements would include provisions ensuring carbon storage either in perpetuity or for a specified time, and the easements would allow monitoring by the entity holding them. Under the three-gear approach delineated above, the Sky Trust could be a receiving entity for these easements.

240. *See* Deanna Lynn, *Landscape Design for Carbon Sequestration, Master's Thesis Presentation*, UNIV. OF OR. (June 5, 2020), https://scholarsbank.uoregon.edu/xmlui/handle/1794/26127 (explaining that landscape architects are increasingly becoming professionally knowledgeable about carbon sequestration).

241. Zachary Griffith, *The Carbon Storage Easement*, UNIV. OF OR. (2021) (on file with author). Other durability tools exist in the form of deed restrictions and contractual obligations.

242. *See* UNIF. CONSERVATION EASEMENT ACT § 1(1) (NAT'L CONF. OF COMM'RS ON UNIF. STATE L. 1982) (providing examples of the types of purposes for which conservation easements may be established).

243. *Id.*

11. Announcement and Outreach

Scaling up the NCS effort depends on recruiting managers of working lands and suitable urban spaces across the region. A core function of the Framework is to announce this epic drawdown challenge in ways that call to tribes, communities, landowners, and leaders to join the effort. The methods for gaining tribal interest will differ from those aimed towards non-Indian rural communities. Tribal outreach characteristically focuses on tribal agencies, tribal leaders, and inter-tribal coalitions. As to the non-Indian rural communities, the success of gaining participants will likely rest on co-creating a compelling narrative coupled with written materials, social media, YouTube videos, and a full range of communications tools to catalyze interest. Carbon is not typically the calling card for engaging rural communities; they may instead be more interested in soil health, water conservation, and local job creation. Experts from the humanities are instrumental in conveying the stories of individuals already engaged in the drawdown project, reporting personal success, surprises, and challenges to inspire others. Community leaders, local influencers, and tribal leaders will be crucial to growing engagement in regions that may otherwise be resistant to or not interested in climate initiatives alone (but interested in the co-benefits drawdown projects may provide). Extensive community-outreach efforts can benefit from broad databases crossing multiple sectors—including rural working-lands associations, granges, community groups, agencies, political offices, philanthropic organizations, food-security groups, and others.

IV. THE PACIFIC NORTHWEST FRAMEWORK FOR ATMOSPHERIC RECOVERY: A MODEL FOR OTHER REGIONS

The process of developing a regional Framework for the PNW is underway and provides a potential model for other regions seeking to launch a similar effort. The PNW is well-positioned to initiate this urgent sky-cleanup project in North America, as it holds vast natural landscapes with all four ecotypes capable of catalyzing a broad drawdown effort.[244] In particular, the PNW's old-growth forests rival the Amazon rainforest in carbon storage, and they also contain immense biodiversity.[245] Without a drawdown project, the region's old-growth forests remain vulnerable to massive carbon releases

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244. Silva et al., *supra* note 75, at 3 ("The PNW is a valuable model system because it encompasses extensive forests, prairies, and riverine wetland systems in public and private ownership as well as rapidly expanding rural-urban interfaces across strong natural climate gradients.").

245. Law, *Creating Strategic Reserves*, *supra* note 11, at 731 ("The PNW and Alaska stand out as having mature and old forests with immense carbon stores and high biodiversity."); *see also* Wood, *The Oregon Forest Trust*, *supra* note 51, at 726 and accompanying text.

through clearcutting.[246] The PNW also has human capacity geared towards carbon drawdown and landscape recovery. Tribal sovereigns across the PNW have exercised leadership in resource protection and recovery and remain at the forefront of national climate leadership.[247] The PNW holds top-flight research universities, non-profit organizations, and land managers that are researching NCS techniques, educating the public about these techniques, and implementing them on a pilot scale.[248] But it still lacks the coordinated effort essential to accelerate this process.

The PNW Framework for Atmospheric Recovery (PNW-FAR) project, led by the University of Oregon's Environmental and Natural Resources Law Center, commenced in 2021 and is expected to culminate in a draft Framework in the Fall of 2024. The discussion below describes the PNW-FAR process after first summarizing the choices involved in defining its regional scope.

A. Defining the "Region" to Catalyze an NCS Enterprise

The first step to embarking on a regional Framework is defining the geographic scope of the region subject to the drawdown effort. In the PNW-FAR process, the organizing team explored different configurations of the "Pacific Northwest." For example, if the bioregion alone defined the framework boundaries, a target area might encompass the old-growth coastal forests, stretching from northern California to southern British Columbia but stopping at the crest of the Cascades. However, that delineation would involve onerous jurisdictional complexities, as the PNW-FAR would reach internationally yet not capture the full state jurisdictions of Oregon, Washington, and California. That bioregional focus would also exclude the NCS opportunities east of the Cascade mountains within the state jurisdictions. If, as another possibility, the region was to be defined as Oregon and Washington alone, the team would exclude much of the salmon's range and leave out tribes in Idaho leading important efforts related to this work.

While dilemmas arise with every possible configuration, the team settled on a Framework region encompassing the traditionally defined Pacific Northwest: the states of Oregon, Washington, and Idaho. This region shares cultural and historic ties stemming back to time immemorial in Indigenous culture and, in non-Indian society, dating back to the establishment of the

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246. *See* Law, *Land Use Strategies*, *supra* note 51.

247. Stephanie Gutierrez, *Taking Action Now: The Tribal Climate Change Project*, ECOTRUST (June 20, 2018), https://ecotrust.org/tribal-climate-change-project/.

248. *See, e.g.*, ALDERSPRING RANCH, *supra* note 87 (providing an example of land managers using regenerative practices).

Oregon Territory in 1848. The region encompasses all four ecosystem drivers of NCS: forests; farmlands; grasslands and rangelands; and blue and teal carbon areas.[249] This region largely coincides with the reach of the Pacific salmon.[250] In terms of jurisdictional and inter-sovereign considerations, the tribes of Oregon, Washington, and Idaho have nationally recognized environmental programs and intertribal agencies as well as firm relationships with the respective states; several tribes are already developing NCS programs on their lands or aboriginal territory outside of reservations.[251] On the state level, Oregon and Washington have established legislative goals on climate policy, and Oregon is exploring NCS potential.[252] While Idaho remains an outlier on climate policy,[253] it has remarkable potential to align NCS strategies with biodiversity-protection goals, as it holds a rich array of land and water habitats for a multitude of species.

B. The Process of Developing a Pacific Northwest Framework for Atmospheric Recovery (PNW-FAR): A Convergence Acceleration Approach

As already emphasized, time is of the essence in developing regional Frameworks, as the crises of today require an urgent response. Typically, environmental policymaking develops in an atomized fashion: knowledge creation begins in the science realm; then eventually reaches the policy realm, where concrete proposals are fashioned; then finally arrives at the leadership level, where policies are enacted as laws or find their way into the marketplace through corporate or private adoption. This process may take many years and often succumbs to political stagnation in the later stages. Abruptly changing circumstances may eclipse work that takes too long and is not amendable to adjustment. The PNW-FAR experiment took another route, seeking to combine multi-disciplinary expertise, tribal knowledge and

249. *See 2023 Natural and Working Lands Report*, OR. GLOBAL WARMING COMM'N, https://www.keeporegoncool.org/natural-working-lands (last visited Mar. 31, 2024) (providing that the four ecosystem drivers are forests, agricultural lands, grasslands and rangelands, and blue and teal carbon).

250. *West Coast Salmon and Steelhead Fisheries Management*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. (Oct. 12, 2022), https://www.fisheries.noaa.gov/west-coast/sustainable-fisheries/west-coast-salmon-and-steelhead-fisheries-management.

251. PNW intertribal agencies and organizations include the Columbia River Inter-Tribal Fish Commission, the Northwest Indian Fisheries Commission, and the Affiliated Tribes of Northwest Indians.

252. S.B. 1534, 81st Legis. Assemb. (Or. 2022), (Proposed Natural and Working Lands Carbon Sequestration bill) (failed).

253. *See Idaho Profile*, CLIMATE XCHANGE, https://climate-xchange.org/network/map/idaho/ (last visited Mar. 31, 2024).

perspective, community insights, and leadership outlooks at once—an "accelerated convergence" approach.[254]

1. The Prospectus

After organizing the core PNW-FAR team at the University of Oregon,[255] the Framework process began with a draft Prospectus capturing the effort ahead.[256] The Prospectus defines the purpose and components of the regional Framework, intended as a platform for bringing people and communities together around the collective vision of land restoration and carbon drawdown. It describes the components above to organize individuals and ideas around different parts of the drawdown-implementation challenge. In the case of the PNW-FAR, the Prospectus became an iterative document undergoing constant revision as perspectives from around the region informed the organizing team.

2. The Prelude Meetings, the Chronicle, and the Collective[257]

After the Prospectus was completed, the organizing team engaged in a three-month period of outreach to individuals and organizations involved in various components of drawdown across the four ecotypes. The team held "Prelude Meetings" through Zoom to engage with scientists, land managers, tribal leaders, agency officials, conservation lawyers, economists, and non-profit organizations across the forest, farmland, grass- and rangeland, and blue- and teal-carbon ecotypes. A working document (called the "PNW-FAR Chronicle") kept track of contact information, organized by ecotype. As information flowed to the organizing team, it was incorporated into the Framework Outline, which would form the backbone of later drafting. This outreach period was crucial to the project as a whole because it announced the effort and began to bring together a community of individuals and organizations around the project. As the Chronicle gained contacts, a loose "Collective" was identified around each ecotype. These are identified

254. *See* Silva & Wood, NSF White Paper, *supra* note 225 ("The task of implementing NCS is urgent and requires accelerated convergence across multiple sectors. Convergence that can transform the promise of NCS into real-world implementation is defined as fundamental research likely to trigger advances through partnerships across multiple disciplines, sectors, and stakeholders (e.g., industry, non-profits, government entities, and the general public) to propel CO_2 drawdown.").

255. Law schools across other regions may serve as ideal Framework organizers due to their research focus, interdisciplinary expertise, and wide-ranging connections. The preliminary effort at University of Oregon began in 2019 with a workshop led by several academics across multiple disciplines at UO, funded by the National Science Foundation's Convergence Accelerator Program. *See id.*

256. Prospectus, *supra* note 2.

257. The description in this section was based on a process led by the author along with Research Associate Tom Housel.

individuals and organizations—potentially hundreds in each ecotype—positioned to coalesce around the regional enterprise of carbon drawdown and ecosystem recovery. The Forest Collective, Farmland Collective, Grassland/Rangeland Collective, and Blue Carbon Collective could form the beginnings of a region-wide movement. Creating the data set encompassing these individuals and organizations forms a core step in the FAR process.

At the same time that this regional outreach took place, the Oregon State Legislature was considering legislation to fund drawdown projects state-wide, and a legislative task force was developing NCS protocols.[258] Similar legislative efforts are likely to start in other regions. The question is inevitable: is the university-led PNW-FAR duplicative of such legislative efforts? The answer should be a confident "no." First, a regional Framework such as the PNW-FAR extends beyond just one state; the PNW-FAR includes the three states of Oregon, Washington, and Idaho. Second, the Framework's wide focus on all implantation barriers and opportunities inevitably integrates aspects not included in state legislative initiatives. Third, legislative efforts may not come to fruition in states (like Oregon) where the rural communities may distrust government climate initiatives.[259] Therefore, a non-governmental effort may access far more individuals who are positioned to catalyze drawdown in their communities. Fourth, a university-led regional Framework is essentially a research project. When developments transpire in the legislative realm, they can be incorporated into the Framework. Indeed, the Framework serves as a broad clearinghouse of information and can explain government programs and funding opportunities in a manner accessible to the communities that can benefit from them.

3. The Working Groups

The next step in the PNW-FAR process was creating "Working Groups" for each ecotype to assist the University of Oregon team in drafting the Framework. The Working Group size was small—8 to 10 people—and individuals were chosen from the broader Collective for each ecotype. The Working Groups help develop the vision of evaluating, accelerating, and scaling up the NCS opportunities in an ecotype. The scientific expertise required in each Working Group is highly interdisciplinary. Some members focus on the Earth's carbon cycle and the atmospheric-terrestrial exchange

258. *See* S.B. 530, 82d Legis. Assemb. (Or. 2023) (proposing to fund NCS projects in Oregon) (failed); *see also 2023 Natural and Working Lands Report*, *supra* note 249 (explaining goals for carbon and storage in Oregon).

259. That was indeed the case in Oregon, where legislative initiatives focused on natural climate solutions have failed two years in a row. *See* S.B. 1534, 81st Legis. Assemb. (Or. 2022) (Natural and Working Lands Carbon Sequestration bill) (failed); S.B. 88, 82d Legis. Assemb. (Or. 2023) (proposing to increase net carbon-sequestration storage in natural and working lands) (failed).

and soil-microbe interactions. Others bring expertise from conservation biology, hydrology, and other disciplines. While the full community of scientists and other experts working on NCS cannot be included in developing the Framework, Working Group participants are positioned to tap and assemble the science from their sectors, much as members of UN working groups (like the IPCC) draw upon international expertise.

Because of the need for accelerated solutions, the Working Group members chosen were individuals that fuse *opportunity expertise* with *implementation and leadership expertise*. In other words, members were selected not only for their professional background and accomplishments, but also for their connections to broader groups and their ability to bring the Framework into multiple forums, including policy circles, rural communities, and administrative agencies. Tribal representatives participated in three of the four Working Groups,[260] and rural-landowner participation was also prioritized. Importantly, members were selected from across the three states of the region, with the goal of roughly spreading geographic representation. Recognizing that the small size of the Working Groups precluded others with valuable expertise and connections, the organizing team created broader "Advisory Groups" for each ecotype as well.

4. The Convening Workshop

A three-day Convening of the four Working Groups was sponsored by the University of Oregon's Environmental and Natural Resources Law Center in May 2023. Held at a lodge with breathtaking views of the Columbia River, the Convening inspired a visionary quest and community-building toward a regional restoration enterprise. The workshop was highly structured, with table participants all contributing to a group OneDrive document that aggregated their input.

The Convening was divided into segments focused on each Framework component described above. In advance of this intensive workshop, the organizing team prepared detailed worksheets with guided questions building upon the protocols. These worksheets provide a model for, and are available to, other regions engaged in the NCS enterprise.

Following the Convening, the next stage is drafting the Framework—a concerted amount of work for one or two individuals in coordination with the Workshop participants. This initial drafting will be followed with dissemination to the Working Groups and Advisory Groups for revision.

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260. Those Working Groups were forest, blue carbon, and farmland. The Framework team could not find PNW tribal engagement in NCS dealing with the rangeland ecotype.

5. Unveiling the PNW-FAR

The dissemination stage culminates the Framework process. In this vein, the Chronicle of interested groups (described above) becomes a database for dissemination and, ultimately, for building a movement around NCS. Because the Framework is not a regulatory or legislative proposal, it lacks the formal adoption and agency administration process that lawmaking would entail. Instead, leading institutions, government entities, and community leaders must build the imprimatur of the effort by formally endorsing the Framework. This is essential, as credibility remains crucial to funders, including courts that award damages for harm to the atmosphere and for adaptation. Later, adoption and funding commitments will confer standing and validity to the Framework.

V. SUSTAINING AND PROLIFERATING THE EFFORT: THE REGIONAL ATMOSPHERIC RECOVERY INSTITUTE

As the world faces the unprecedented climate challenge, new institutions must emerge to tackle the global imperative of regaining the planet's energy balance. The atmospheric-drawdown endeavor is projected to continue through the end of the century. Ultimately, to maintain this effort and create a mechanism for adaptation to both changing natural conditions and evolving scientific understanding, regional Atmospheric Recovery Institutes (ARIs) are necessary. An ARI need not be a governmental entity—it may best function as an independent institution created by a consortium of partners from research universities, tribes, agencies, and non-profits. As the institutional home for the Framework, the ARI will verify, aggregate, and amplify emerging best available NCS science as it evolves, incorporating Indigenous knowledge as explained above.

Supporting regional landscape restoration into the future requires continually updating and expanding the Framework. The ARI will regularly revise the field protocols, maintain and update the regional-opportunity map, shape the investment portfolio in response to new information and changing climate conditions, provide education and training, and assess the overall progress of the NCS strategies. Operating as a regional information hub, the ARI will not generate all or even most of the research needed for the drawdown endeavor[261] but rather will serve as a catalyzing, organizing entity that synthesizes information produced by others and steers a transdisciplinary endeavor from concept to practical implementation.

261. For example, scientific studies examining the effectiveness of NCS techniques will be produced by the scientific community outside of the ARI.

The ARI must have the institutional capacity and longevity to: (1) serve as a third-party monitor verifying the carbon removal achieved by the drawdown projects; (2) evaluate terrestrial processes and conduct a macro carbon accounting on the regional scale to estimate drawdown; (3) assess the progress under the Framework against the benchmark goals and report progress to the regional community of leaders, scientists, analysts, and citizens; (4) modify the Framework according to adaptive-management principles, taking into account opportunities from emerging methods and technology; (5) develop, support, and synthesize science that forms the backbone of NCS; (6) promote narratives from landowners engaged in NCS projects; and (7) serve as a model, proliferating the regional atmospheric recovery project to other regions both nationally and internationally.[262]

In any given region, top-flight research universities already engaged in climate research may be best situated to host a Regional ARI on their campuses. The benefits to any institution of higher education are obvious. The Institute would enjoy an enviable position at the center of a historic collaborative scientific endeavor, researching and advancing projects to protect the planet's habitability and promote the well-being of all generations to come. Such a university would seemingly attract students from around the world who are drawn to the crucial public mission of the Institute and who wish to engage in the applied educational opportunities it offers. A robust educational and experiential component would train a league of professionals to deploy the strategies and techniques comprising the Regional FAR. The Institute would create new career paths for students dealing with carbon accounting, ecosystem modeling, carbon-storage technology, and carbon landscape architecture, among others. Through the Institute, in-house researchers, professors, and students at the university would have the opportunity to interact and collaborate with top professionals and visionaries worldwide. The Institute could also serve as a launch pad for products designed by university researchers to promote carbon sequestration.

Impressive institutional models outside of higher education exist as well. One possible model is an independent think tank similar to the Stockholm Institute, which plays a role in climate policy on the global level, or the Woods Hole Oceanographic Institution, an independent research entity that partners with the Massachusetts Institute of Technology to offer programs and degrees to undergraduate and graduate students.[263] Another model is a government-created institution, such as the Pacific Northwest National

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262. Notably, these functions differ greatly from—and reach well beyond—those carried out by two other existing climate centers in the Pacific Northwest such as the Oregon Climate Change Research Institute or the Northwest Climate Adaptation Science Center.

263. STOCKHOLM ENV'T INST., https://www.sei.org (last visited Mar. 31, 2024); WOODS HOLE OCEANOGRAPHIC INST., https://www.whoi.edu (last visited Mar. 31, 2024).

Laboratory (and similar institutions across the U.S.).[264] But while each model has distinct advantages, a university consortium forming an independent entity holds the advantage of a continually replenishing student body, which can form the lifeblood of a multi-generational project. An inspired, well-trained student body may create incalculable ripple effects across the world through the natural outreach that students extend to their communities. In that way, students may become the agents through which exponential impact from the regional ARI can be realized on a global level.

Crucially, the ARI must be designed such that it is not wholly embedded within, or governed by, a single university, as it must not be servient to any institutional objectives or structure other than its own. An ARI having allegiance to the region may best materialize as a consortium of institutions affiliated with a primary "hosting" university that provides the physical locus. Regardless of the Institute's composition, the ARI must remain fiercely independent, transparent, have unimpeachable integrity, and stay nimbly positioned to detect and rapidly incorporate the dynamic forces of natural and social change in the regional atmospheric recovery effort.

CONCLUSION

Amidst a clear planetary emergency, the next few years will prove critical to preserving the habitability of Earth for the world's children and future generations. To bring atmospheric CO_2 below 350 ppm, global society must accomplish a massive sky cleanup of excess legacy carbon pollution. As this Article has explained, the current offset market defeats necessary cleanup by justifying the addition of more pollution to the atmosphere, thus negating any progress towards actual sky cleanup of legacy carbon. This Article has focused on catalyzing and scaling up natural climate solutions to begin CO_2 drawdown and sequestration across four ecotypes—forests, farmlands, grasslands and rangelands, and blue and teal carbon areas (such as estuaries and wetlands). While many tribes, land managers, organizations, and research institutions across the world have been researching and implementing many of these NCS techniques on a site-specific basis, the efforts remain disparate and disconnected. A coherent, aggregating approach is needed to accelerate and scale up the carbon-cleanup effort, harnessing regional capacity around the world.

This Article proposed the development of regional Frameworks addressing opportunity in the four ecotypes. The Frameworks will announce opportunities to land managers; provide an implementation blueprint and pricing for NCS techniques; discern co-benefits and biodiversity goals as

264. PAC. NW. NAT'L LAB'Y, https://www.pnnl.gov (last visited Mar. 31, 2024).

well as drawbacks; identify justice issues and opportunities; provide methods to monitor progress; evaluate legal mechanisms (such as conservation easements) to ensure the durability of NCS projects; identify major funding sources for NCS projects; and develop communications and outreach approaches to gain buy-in from landowners. A process developing such a Framework is underway in the Pacific Northwest with the aim of becoming a model for the world.

The Framework is not a regulatory or legislative proposal but rather a research initiative. As such, it becomes the platform around which a regional movement can grow. The Framework calls broadly for society to recover degraded natural systems across all communities, which increasingly face existential threats from the droughts, floods, storms, fires, heat domes, and human dislocation that climate disruption brings. While sequestering carbon, many NCS techniques will stabilize soils, improve food productivity, reduce erosion and water pollution, protect against coastal flooding, and recover biodiversity. Ultimately, the Regional Framework suggests a different way of living on the landscape by recommending that Humanity harmonizes with the processes that support our own survival. To this end, future frameworks should draw upon the wisdom of tribal people gained over generations of ecological experience on their aboriginal lands.

Developing Regional Frameworks is no small undertaking. The process requires convening experts from multiple disciplines and thought leaders from various sectors, drawing them into a collaborative enterprise to envision a fundamental shift in land management across a region. Of course, any such effort inevitably confronts societal inertia that can hinder progress. But the tangible prospect of land and resource recovery may create its own irresistible social momentum, particularly when juxtaposed against the increasingly recognized prospect of runaway planetary heating and incalculable human loss and suffering. As Winston Churchill famously declared, *"It's not enough that we do our best; sometimes we have to do what's required."*[265]

265. FORBES: QUOTES, https://www.forbes.com/quotes/10319/ (last visited Mar. 31, 2024).