DAY ONE PROJECT

Pathways to Net-zero Soil Loss by 2050

November 2021

FAS

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Introduction

The current administration should announce its intention to achieve net-zero soil loss by 2050. This target aligns with President Biden's plan to "mount a historic, whole-of-Government-approach to combating climate change,"[1] would help fulfill the administration's commitment to achieving a net-zero-emissions economy by 2050,[2] and is key to protecting our nation's agricultural productivity.

Healthy soil is essential to food production. Less well recognized is the vital role that soil plays in climate modulation. Soil is the largest terrestrial carbon repository on the planet, containing three times the amount of carbon in Earth's atmosphere.[3] Soil represents a potential sink for 133 billion tons of carbon (equal to 25 years of U.S. fossil-fuel emissions).[4,5] Using soil to offset emissions generates significant co-benefits. Carbon sequestration in soil nourishes soil ecosystems by improving soil architecture and increasing water-holding capacity. Deeper and more fertile soil also supports biodiversity and enriches natural habitats adjacent to agricultural land.

Over two-thirds of the United States is grassland, forestland, and cropland.[6] Land practices that increase the amount of carbon stored underground[7] present a relatively low-cost means for President Biden's administration to pursue its goal of net-zero carbon emissions by 2050.[8] But lost soil can no longer serve as a carbon repository. And once lost, soil takes centuries to rebuild. Increasingly extreme climate events and soil-degrading industrial farming practices are combining to rapidly deplete our nation's strategic soil resources. The United States is losing 10.8 tons of fertile soil per hectare per year: a rate that is at least ten times greater than the rate of soil production.[9] At this rate, many parts of the United States will run out of soil in the next 50 years; some regions already have. For example, in the Piedmont region of the eastern United States, farming practices that were inappropriate for the topography caused topsoil erosion and led to the abandonment of agriculture.[10,11] The

[1] The White House. (2021). FY 2022 Discretionary Request. Office of Management and Budget, April.
[2] The White House. (2021). FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies. April.
[3] Ontl, T.A.; Schulte, L.A. (2012). Soil Carbon Storage. *Nature Education Knowledge*, *3*(10): 35.
[4] Sanderman, J.; Hengl, T.; Fiske, G.J. (2017). Soil carbon debt of 12,000 years of human land use. Proceedings of the National Academy of Sciences, 114(36): 9575–9580.
[5] Ritchie, H.; Roser, M. (2020). Fossil Fuels. Our World in Data, November.
[6] U.S. Department of Agriculture [USDA]. (2020). USDA ERS - Major Land Uses. Economic Research Service, April.
[7] USDA. (2020). USDA ERS - Climate Change. Economic Research Service, August.
[8] Creyts, J.; et al. (2007). *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost*. McKinsey & Company.
[9] Pimentel, D.; Burgess, M. (2013). Soil Erosion Threatens Food Production. *Agriculture*, 3(3): 443–463.
[10] Andersen, C.; Donovan, R.; Quinn, J. (2015). Human Appropriation of Net Primary Production (HANPP) in an Agriculturally-Dominated Watershed, Southeastern USA. *Land*, 4(2): 513–540.
[11] Daniels, R.B. Soil Erosion and Degradation in the Southern Piedmont of the USA. In: Wolman, M.G.; Fournier, F.G.A. [Eds.]. (1987) *Land Transformation in Agriculture*. New York: John Wiley and Sons. 407–428.

northwestern Palouse region has lost 40–50% of its topsoil,[12] and one-third of the Midwest corn belt has lost all of its topsoil.[13]

Soil loss reduces crop yields, destroys species' habitats that are critical to food production, and causes high financial losses. Once roughly half of the soil is lost from a field, crop yields and nutrient density suffer. Maintaining a desired level of agricultural output then requires synthetic fertilizers that further compromise soil health, unleashing a feedback loop with widespread impacts on air, land, and water quality — impacts that are often disproportionately concentrated in underserved populations.

Climate change and soil erosion create a dual-threat to food production. As climate change progresses, more extreme weather events like intense flooding in the northeastern United States and prolonged drought in the Southwest make farmland less hospitable to production. Concurrently, soil erosion and degradation release soil carbon as greenhouse gases and make crops more vulnerable to extreme weather by weakening the capabilities of plants to fix carbon and deposit it in the soil. Halting soil erosion could reduce emissions, and building stable stores of soil carbon will reduce atmospheric carbon.

Prioritizing soil health and carbon sequestration as a domestic response to the climate and food-security crises is backed by centuries of pre-industrial agricultural practices. Before European occupation of tribal lands and the introduction of "modern agricultural practices," Indigenous peoples across North America used soil protective practices to produce food while enhancing the health of larger ecosystems.[14] Some U.S. farmers adhere to principles that guide all good soil stewardship — prevent soil movement and improve soil structure. Practices like no-till farming, cover cropping, application of organic soil amendments, and intercropping with deep-rooted prairie plants are proven to anchor soil and can increase its carbon content.[15,16] In livestock production, regenerative grazing involves moving animals frequently to naturally fertilize the soil while allowing plants to recover and regrow. If all farms implemented these practices, most soil erosion would halt. The challenge is to equip farmers with the knowledge, financial incentives, and flexibility to use soil-protective techniques.

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[12] Ebbert, J.C.; Dennis Roe, R. (1998). *Soil Erosion in the Palouse River Basin: Indications of Improvement*. U.S. Geological Survey, July.
[13] Thaler, E.A.; Larsen, I.J.; Yu, Q. (2021). The extent of soil loss across the US Corn Belt. Proceedings of the National Academy of Sciences, 118(8): e1922375118.
[14] Norton, J.B., et.al (2002). Native American methods for conservation and restoration of semiarid ephemeral streams, *Journal of Soil and Water Conservation,* 57(5): 250- 258
[15] Helmers, M.J. (2014). STRIPS: Science-Based Trials of Row Crops Integrated with Prairie Strips. *Engineering & Technology for a Sustainable World*, 21(32): 12–13.
[16] Iowa State University. (2021). What Are Prairie Strips? Science-Based Trials of Rowcrops Integrated with Prairie Strips.

This document recommends a set of actions that the federal government — working with state and local governments, corporations, research institutions, landowners, and farmers — can take towards achieving net-zero soil loss by 2050. These recommendations are supported by policy priorities outlined in President Biden's Discretionary Budget Request for Fiscal Year 2022 and the bipartisan infrastructure deal currently under negotiation in Congress. Throughout, we emphasize the importance of (1) prioritizing storage of *stable* carbon (i.e., carbon that remains in soils for the long term) and (2) addressing environmental injustices associated with soil erosion by engaging a broad group of stakeholders.

Firm commitments to restore degraded land will establish the United States as an international leader in soil health, help avoid the worst impacts of climate change, strengthen food security, advance environmental justice, and inspire other countries to set similar net-zero targets. The health of our planet and its people depend on soil preservation. Our nation can, and should, lead the way.

Plan of Action

Action 1. Become a signatory of "4 per mille," the international initiative encouraging countries to collectively increase global soil carbon by 0.4 percent per year.

The United States should officially join the international effort, "4 per mille" (4p1000), and commit to increasing stable soil carbon by at least 0.4 percent per year. By signing onto this effort, President Biden would send a powerful message of appreciation for U.S. conservation farmers and signal to the rest of the world that soil and forest management are important strategies for mitigating and adapting to climate change.

Detractors of 4p1000 have raised concerns about its feasibility, measurement, and accountability. These arguments obscure the target's intent: to motivate a global effort to sequester carbon in soil and avert the worst of anthropogenic climate change. The target gives countries a tangible and common goal to work towards as they identify and implement the soil-carbon sequestration strategies that will work best in their respective domestic environments.

Before COP26, the White House Office of Science and Technology Policy, in partnership with the Secretary of Agriculture and the Biden administration's climate-change leaders (John Kerry and Gina McCarthy), should develop a strategy to accompany the United States' endorsement of 4p1000 and garner endorsements of the agreement from other nations. A central pillar of this strategy should focus on developing and deploying inexpensive methods to estimate soil carbon. These new

tools would help farmers track their net carbon increases and ensure that carbon emissions from soil are not negating their efforts.

This action could be supported by funds allocated to the Department of State for multilateral climate initiatives, Department of Interior funding for ecosystem resilience among all land-management agencies, and USDA's renewed investment to engage landowners to combat climate change and increase participation in voluntary conservation.

Action 2. Invest in a data repository for agriculture and soil carbon.

Advances in soil health of agricultural systems, like advances in human health, will depend on the sector's capacity to aggregate and refine big data. This capacity is needed to develop comprehensive decision-support tools underpinned by hyper-local data in a publicly accessible and well-maintained database.

USDA's Agricultural Research Service currently supports a data repository through its National Agricultural Library (NAL). The NAL repository houses datasets generated by USDA researchers and other USDA-funded research. Unfortunately, the NAL repository is poorly equipped to handle data originating from additional sources. Nor does the NAL repository support the industry-wide annotation system needed to make data searchable and comparable.

A new repository is needed. The National Library of Medicine (NLM) offers an excellent model in GenBank. By helping researchers compare genes, this open-access bioinformatics tool deepens our understanding of health and accelerates development of medical treatments. GenBank connects to similar databases worldwide, and researchers contribute to and search the databases with associated software. The National Weather Service (NWS) similarly compiles a massive set of weather data[17] that supports research and generates income from business services. Both GenBank and the National Weather Service's databases have supported an explosion of resources, products, and services, from diagnostic medical tests, precision medicine, and genetic testing[18] to weather apps for phones. These databases also feature budgets an order of magnitude larger than the budget for USDA's NAL.

A right-sized investment in a broad agricultural research database at the NAL, including data generated with proprietary smart-farm technologies and other public-private collaborations, is the future of modern agriculture and agriculture research. Nationally available, high-quality, and curated agricultural data would seed a wealth

[17] National Oceanic and Atmospheric Administration. (2021). National Centers for Environmental Information.
[18] Dangi-Garimella, S. (2020). How GenBank, Databases Speed Vaccine, Drug Development-and Precision Medicine. AJMC.

of new services and companies in the sector. The database would also support the implementation of reliable, locally tailored, and situationally relevant soil-management practices and decision tools that provide precision health practices for soil.

Specifically, we recommend that USDA take the following steps to establish a broad agricultural data repository:

- Increasing the NAL's budget by at least tenfold (moving closer to the level of funding enjoyed by the NLM) as its storage capacity expands.
- Working with the NLM and the NWS to learn from their decades of experience in building robust public data repositories.
- Constructing a repository that can house a broad range and large volumes of agricultural data, as well as the software needed to make the data findable, accessible, interoperable, and reusable. The database should accept data from research projects, farming operations, and Farm Bill conservation programs. Care must be taken to ensure that data from farms is anonymized and confidential.
- Hiring specialists to develop software for extracting, standardizing, formatting, and uploading data directly from research and farming equipment.
- Working with research- and farm-equipment designers to ensure their products can collect data in a format that matches USDA's database requirements and is easy to use by farmers and farmworkers.
- Offering training and tools to familiarize researchers and students with the repository's structure and assets and encourage researchers and students to link data to publications using Persistent Unique Identifiers (PUIDs).

These steps could be carried out using discretionary funding at USDA earmarked for investments in research and development capacity of farmers. These steps collectively align with the administration's goal to "support a multi-agency initiative aimed at integrating science-based tools into conservation planning and verifying stable carbon sequestration, greenhouse-gas reduction, wildlife stewardship, and other environmental services at the farm level and on federal lands."[19]

Action 3. Invest in targeted research to reduce soil erosion and increase carbon sequestration.

General factors contributing to soil loss and mitigation principles are universal. Still, the most effective combination of specific practices for reducing soil erosion and increasing carbon sequestration depends on local soil type, slope, soil condition, land

[19] The White House. (2021). FY 2022 Discretionary Request. Office of Management and Budget, April.

use, and weather. In many farming settings, regenerative practices can increase soil carbon and eliminate soil erosion in as little as one or two growing seasons. But matching best practices to a given location can be complex.

For example, intensive tillage is the most soil-erosive practice in agriculture. Reducing the use of this practice has been an important goal for soil-preservation efforts over the last four decades. Organic farms frequently use intensive tillage because organic certification prohibits the use of genetically engineered plants or herbicides—even though herbicide treatment provides excellent weed control and genetic engineering has made it possible to suppress weeds using herbicides without damage to the engineered crop plant. Reducing soil erosion on organic farms hence requires research into new methods of weed control.

The USDA National Institute of Food and Agriculture (NIFA) and the National Science Foundation (NSF) should jointly fund competitive grants for research into practices that reduce soil erosion, increase the nutrient density of food, and sequester carbon stably. Priority projects of these grants might include:

- Alternatives to intensive tillage for weed control, such as intercropping with competitive plant species, inhibiting weed growth with compost or other additives, planting cover crops that leave a residue that inhibits weeds but not crop plants, or application of weed-killing compounds that are acceptable under organic-certification requirements.
- Decision-support tools that help farmers choose strategies to reduce erosion in a financially viable manner.
- Methods to increase soil-carbon stability.
- Rapid, inexpensive tests to track soil carbon. Such tests would improve accountability and precision of farmer efforts to sequester carbon.
- Methods to integrate remote-sensing data with on-the-ground measurements of soil erosion.

As with Action 2, these steps could be carried out using discretionary funding at USDA earmarked for investments in farmers' research and development capacity. These steps collectively align with the administration's goal to support a multi-agency initiative to integrate science-based tools into conservation planning and verify stable carbon sequestration, greenhouse-gas reduction, wildlife stewardship, and other environmental services at the farm level on federal lands.

Action 4. Develop financial and educational programs that help farmers transition to soil-protective practices.

Soil-protective practices have agronomic and economic benefits. Farmers using continuous no-till methods save several thousand dollars each year due to reduced fuel and labor investments.[20] But economic returns on soil-saving practices can take several years to accrue. Growers are rightly concerned about their financial solvency in the short term should they implement such practices, as well as about yield reductions associated with no-till agriculture in some cases.[21] USDA should (i) provide financial assistance to help producers transition to soil-saving practices and (ii) offer training to help producers realize maximal benefits of soil-protective practices at each phase of the transition.

For instance, USDA's Farm Service Agency (FSA) could offer loans based on cost-saving projections from reduced need for synthetic inputs and increased potential yield once the transition to soil-protective practices is complete. For example, loans could cover the cost of the first five years of projected lost income per acre. At the end of this term, USDA's Risk Management Agency (RMA) could offer discounted crop insurance rates because the now-healthier soil would engender a more resilient system less likely to experience catastrophic losses during floods and droughts. Farmers could use savings on insurance costs to repay loans and keep premiums constant once repayment begins.

Participation in the loan program could be contingent on farmers' capacity to maintain soil-protective practices for at least ten years. During the initial five-year loan period, soil-health specialists affiliated with USDA could provide farmers with training on measuring progress, collecting data, and uploading that data to a centralized database. Outcomes across participating farms could be tracked and iteratively inform best practices during the transition period. After the initial five-year period, farmers could qualify for a five-year loan-forbearance period if they demonstrate continued participation in the program.

USDA could also offer direct payments to farmers participating in soil revitalization. Another Day One Project policy proposal recommends[22] that the USDA offer incentive payments for climate-smart practices that produce ecosystem services if the producer cannot find a buyer through an ecosystem-services market.

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[20] Creech, E. (2017). Saving Money, Time and Soil: The Economics of No-Till Farming. USDA.
[21] Pittelkow, C.M.; et al. (2015). When does no-till yield more? A global meta-analysis. *Field Crops Research*, 183: 156–168.
[22] Posner, S (2020). A National Initiative to Revitalize American Farming and Advance Regenerative Agriculture. Day One Project.

Specifically, we recommend that USDA take the following steps to develop financial and educational programs that help farmers transition to soil-protective practices:

- Create bridge loan products for farmers based on projected savings, potential yield increases, and ecosystem services provided by transitioning to soil-enhancing farm practices.
- Provide a seed investment for an ecosystem services market.
- Enact a "Good Farmer Discount"[23] on crop insurance for producers already practicing soil conservation and regeneration.
- Hire or train soil health experts through USDA Extension offices to support farmers transitioning to soil-protective practices with ongoing education and training.

These steps could be supported by discretionary funding at the Department of Treasury earmarked for investments in American communities and small businesses and USDA funds dedicated to growing rural economies. These steps align with President Biden's commitment[24] to expanding the role of Community Development Financial Institutions (CDFIs), which offer loans to start-ups and small businesses in rural communities and create new markets for reaching a net-zero carbon economy by 2050.

Action 5. Develop circular economy practices for young entrepreneurs supporting soil conservation.

Small businesses have a significant role in post-pandemic recovery by providing jobs and combating the climate crisis through innovation. The path to a net-zero carbon economy by 2050 must include circular economy principles that design waste out of economic cycles, keep products and materials in use, and regenerate natural systems.[25] Additionally, closing education gaps and creating new paths to secure jobs for young people who did not complete high school has transformational effects on economic opportunities, health, and life expectancy.[26, 27]

USDA, the Small Business Administration (SBA), and the Minority Business Development Administration (MBDA) should jointly develop a "Ground Up" program that (i) engages the agriculture industry in identifying circular-economy business

[23] Multiple Authors. (2021) Strengthening the Economy, Health, & Climate Security through Resilient Agriculture and Food Systems, April.
[24] The White House. (2021). FY 2022 Discretionary Request. Office of Management and Budget, April.
[25] Ellen MacArthur Foundation. (n.d.). What is the circular economy?
[26] Johnson, E.D.; Strange, M.; Madden, K. (2010). The Rural Dropout Problem: An Invisible Achievement Gap. The Rural School and Community Trust.
[27] National Bureau of Economic Research. (2007). The Effects of Education on Health.

opportunities and (ii) engages young people without a high-school education in starting small businesses that conserve, restore, and protect soil and other natural resources. Ground Up would fill gaps created by the uneven and insufficient USDA Extension workforce in underserved and under-resourced communities. Ground Up would also provide more extensive business and entrepreneurship training than is typically possible through Extension programs. By leveraging relationships with industry partners, program participants could be connected to byproducts—or "wasted resources"—they need to start a circular business and access to mentoring and markets required to sell their products and services profitably. For example, a Ground Up enterprise might incorporate grounds from commercial or residential coffee-making operations or municipal waste into commercial compost production. The Participants who complete the Ground Up program would be eligible for no-interest federal business loans, with repayment required once the business was profitable. The federal government could partner with Community Development Financial Institutions (CDFIs) to share the cost of loans and build connections among young entrepreneurs, Extension professionals, and potential partner businesses.

Specifically, we recommend that USDA and the White House take the following steps to develop circular economy practices for young entrepreneurs supporting soil conservation:

- Establish the "Ground Up" program with $25 million per year for five years. This funding would cover the costs of training instructors, building partnerships with industry, and supporting administrative staff. This funding would also initially cover the costs of loans to eligible small businesses, though loan repayment would replenish these funds in the long term. A comprehensive program evaluation should be conducted at the end of the five years to evaluate program accomplishments and suggest improvements for the next program iteration.
- Direct its Extension offices to collaborate with the SBA to design and implement "Ground Up" training and propose a program founded on circular economy principles.
- In collaboration with the SBA, build and leverage relationships with industries and localities to supply start-up resources and secure advance-purchase commitments that curb investment risk.
- The White House can demonstrate support by hosting a public launch event for the "Ground Up" program. The launch event would highlight commitments from cities and industry partners to participate in and advance the program.

These steps could be implemented using discretionary funds within USDA, SBA, and MBDA earmarked to support innovative multi-agency business opportunities for rural

and minority entrepreneurs. These steps align with the SBA's commitments help small businesses combat climate change and invest in underserved entrepreneurs; the USDA's mandate to grow rural economies and foster innovation in the agricultural sector, as well as USDA's dedication to increasing and protecting biodiversity through good farm stewardship; and the MBDA's economic-development grants aimed at addressing long-standing racial inequity for minority-owned firms.

Action 6. Support diversity in the agricultural workforce pipeline.

People of color, including Black, LatinX, and Indigenous people, are underrepresented in agriculture and agricultural sciences. To begin addressing this underrepresentation, the Biden administration should ensure diversity in its proposed Civilian Climate Corps (CCC). The CCC is envisioned as a modern-day equivalent of the Depression-era Civilian Conservation Corps work-relief program. The new iteration focuses on enhancing conservation and climate-smart practices across the country. The new CCC represents a terrific way for the Department of the Interior (DOI) to train a diverse workforce in climate- and soil-smart land-management practices with clear pathways to careers in technical assistance, agribusiness, and academic agricultural research, among others.

The administration can boost diversity in agricultural research by directing the USDA's Office of Civil Rights and the National Institute of Food and Agriculture (NIFA) to conduct an in-depth assessment of challenges faced by researchers of color in agricultural science and develop discipline-wide plans to address them. The administration can also increase research funding and funding for research infrastructure targeted at underrepresented populations. Students from disadvantaged backgrounds are more likely to choose fields with reliable funding. The relative lack of funding for agricultural sciences, as evidenced by outdated educational infrastructure and shrinking training programs, puts agriculture departments at a stark disadvantage compared to the modern facilities (and reliable post-graduate incomes) of other scientific departments (e.g., biomedicine). The National Science Foundation (NSF) should support research and facilities at Historically Black Colleges and Universities (HBCUs) to demonstrate and communicate programmatic stability and cutting-edge innovation in agriculture.

Specifically, we recommend that the Biden administration take the following steps to support diversity in the agricultural-workforce pipeline:

- Direct the Secretary of the Interior and Secretary of Agriculture to (i) prioritize and focus on diversity in recruitment in their strategy for the proposed Civilian Climate Corps, and (ii) ensure that the CCC includes professional development programs that connect participants to careers in agriculture.

- Boost direct support for graduate student fellowships from 1.5 to 5% of USDA's total extramural research budget. Graduate fellowships put research dollars in the hands of students, and fellowships can be targeted at underrepresented populations. Increasing direct support would provide students with reliable funding while sending a powerful message to those students that they belong in the agricultural sciences and are needed.
- Integrate fellowship programs with USDA's 1890 National Scholars Program so that students at the 1890s HBCUs and other minority-serving institutions (MSIs) have a clear path toward further academic study in agricultural science.
- Increase award size for Higher Education Challenge Grants and the Higher Education Multicultural Scholars Program.
- Require every NIFA grant proposal to include a diversity statement and record of training diverse scientists; mandate consideration of these materials in funding decisions. Proposals for conference grants should additionally address plans for ensuring accessibility and inclusion at the conference.

These steps could be supported by funding allocated at USDA, NSF, and DOI to increase racial equity, specifically the participation of historically underrepresented people in the Civilian Climate Corps and farming, science, and engineering more broadly.

Action 7. Fund existing and proposed advanced research projects agencies (ARPAs) to invest in soil-saving research.

USDA's research agencies tend to fund low-risk research that delivers incremental changes in agricultural practices. This essential research provides many strategies for stemming soil loss, but remarkably few farms employ these strategies. The nation needs paradigm-shifting advances that farmers will use. The Advanced Research Projects Agency (ARPA) model can help realize such advances by investing deeply in bold ideas outside of mainstream thinking. Several existing and proposed ARPA programs are well-positioned to invest in soil-saving research.

ARPA-Energy (ARPA-E) in the Department of Energy (DOE) is already funding high-impact agricultural research that protects soil. ARPA-E has invested in one soil-centered project, ROOTS, to develop "root-focused" plant cultivars that could dramatically reduce atmospheric carbon. The agency is also gearing up for a new project on carbon farming. These projects match ARPA-E's energy-focused mission, which includes reducing greenhouse gases in the atmosphere. However, ARPA-E does not have the mandate to invest in specific agricultural projects that build and protect soil. Two additional ARPA-style entities have been proposed that could do so instead: ARPA-I (infrastructure), included as part of the bipartisan Infrastructure

Investment and Jobs Act, and AgARDA, a USDA-based ARPA-style agency authorized by the 2018 Agriculture Improvement Act (Farm Bill). If funded, ARPA-I, AgARDA, or both could invest in groundbreaking research to drive soil protection.

To leverage the ARPA model for transformative advances in soil-saving research, we recommend that the Biden administration:

- Expand the potential for soil-saving projects at funded ARPA agencies (e.g., ARPA-E) that align with the missions of their parent departments.
- Prioritize a strategic plan for AgARDA that includes ARPA-style independence in its management, an allocation plan for its authorized annual $50 million budget, and structures to empower funding risky but potentially catalytic agricultural projects.
- Promote the role of soil at proposed ARPA agencies (e.g., ARPA-I).

These steps could be supported by discretionary funds allocated to the DOE and USDA. Cumulatively, the President's most recent budget request directs $1.1 billion to DOE to support breakthroughs in climate and clean-energy research and solutions. Specifically, mitigating and adapting to the climate crisis involves more than inventing cleaner energy; new technologies that help farmers protect soil and fix carbon into the land will also be essential for correcting extreme imbalances in the global carbon budget.

Action 8. Develop criteria and funding for "Earth Cities."

People feel helpless and fatigued about climate change at the local level partly because they lack the agency to make positive steps to remove greenhouse gases from the atmosphere. The White House should deepen its relationships with mayors and nonprofit coalition groups of cities—such as C40, U.S. Conference of Mayors, and the National League of Cities— to engage urban communities in combating hazards related to climate change.

Like the Arbor Day Foundation's "Tree Cities" program that encourages communities to steward their tree resources, a national "Earth Cities" program would recognize cities leading the way on urban soil stewardship and management. Criteria for receiving the "Earth City" designation could include implementation of a centralized municipal composting program, large-scale replanting of public parks and rights-of-way with native grasses and perennials that have soil-health benefits, creative management of excavated soil and rock generated by urban construction, becoming a signatory to the 4p1000 initiative, and observance of World Soil Day on December 5. Taking steps to become an "Earth City" and prioritizing soil management at the

municipal level offers communities a way to make a positive difference and experience benefits locally while addressing global climate challenges.

Recent research demonstrates that temperatures can vary as much as 20 degrees across different neighborhoods within the same city. Urban heat islands often overlap with communities of color and low-income households in areas with few trees and large amounts of heat-trapping pavement. In these historically redlined communities, rates of heat-related illness and deaths are also higher than wealthier, whiter, and cooler parts of town[28]. Additionally, meeting green building codes and keeping federally supported housing projects affordable has become increasingly difficult in urban centers. Tending to soil health by reusing excavated soil, planting trees and tall grasses on site, and creating more green spaces can inexpensively mitigate the urban heat-island effect while increasing access to nature in historically under-resourced communities. A partnership between soil experts at USDA, pollution and environmental-hazard experts at EPA, and affordable housing programs at the Department of Housing and Urban Development (HUD) would support cities with funding and implementation and further strengthen program viability by tying federal support to local soil stewardship practices.

Specifically, we recommend that the Biden administration take the following steps to recognize and support cities striving to preserve soil and enhance soil-carbon sequestration:

- Work with USDA, HUD, and EPA to convene a coalition of mayors, soil experts, private industry, developers, nonprofit organizations, and local soil stewards to design the "Earth Cities" program, including establishing qualifying criteria.
- Create an earmarked fund at HUD that supports developers with low-income housing tax credits for implementing and maintaining soil stewardship practices in alignment with the "Earth City" designation.
- Provide seed funding to municipal agencies via state Environmental Protection Agencies to develop soil conservation and restoration programs at the local level.

These steps could be supported through earmarked funds at EPA for the Accelerating Environmental and Economic Justice Initiative, HUD funds to modernize and rehabilitate public housing, infrastructure, and facilities in historically underfunded and marginalized communities; and USDA funds that encourage conservation and increased biodiversity on private land.

[28] Hoffman, J.S.; Shandas, V.; Pendleton, N. (2020). The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas. *Climate*, 8(1): 12.

Action 9. Plant deep-rooted perennials on median strips to foster carbon-rich soils for multi-benefit surface transportation

As a part of President Biden's plan to invest in multi-benefit transportation infrastructures, a policy to populate median strips with deep-rooted prairie perennials presents a means to restore soil carbon and simultaneously sustain essential pollinators in agricultural and other ecosystems. Highway medians are supposed to be at least 50 feet wide for safety,[29] creating a minimum of 6 acres of median per mile of highway. The 47,000 miles of U.S. Interstate[30] and 160,000 miles of other highways amount to nearly 300,000 and 1 million acres, respectively, of median strips in the United States.[31,32] Each acre could sequester 1.7 tons of carbon per year until the soil's carrying capacity is reached.[33]

Deep carbon stores of soil in the Midwest resulted from centuries of growth of perennial plants that store most of their carbon in their roots. The crops that replaced the prairies shunt most of their carbon to the harvested aboveground tissues, leaving little in the soil. Corn roots, for example, represent only 1% of the plant biomass by the end of the growing season, whereas the roots of perennials—which can grow to as deep as 15 feet underground—can account for as much as 70% of the plant's biomass. Between 2009 and 2015, 53 million acres of U.S. land was converted from native vegetation to cropland, leading to a loss of 2% of the soil carbon stored in that land per year. This loss translates to 3.2 gigatons of carbon dioxide released into the atmosphere—equivalent to almost one-half of annual U.S. fossil-fuel emissions.[34]

One way to mitigate soil loss is by planting highway median strips with the native, deep-rooted perennials that simultaneously nourish pollinators, enrich soil, and sequester copious amounts of carbon. The Department of Transportation (DOT) could coordinate a large-scale highway-replanting initiative through the effort proposed in the bipartisan infrastructure bill to rebuild the interstate system. In parallel, federal and local "Adopt-a-Highway" programs could enlist citizens, businesses, and municipalities in seeding median strips with native plants.

Specifically, we recommend that:

- President Biden issues an Executive Order mandating that DOT invest 0.5% of federal highway construction and repair budgets in planting native plants in

[29] Federal Highway Administration. (1993). The Association Of Median Width And Highway Accident Rate. U.S. Department of Transportation. FHWA-RD-93-046.
[30] Federal Highway Administration. (2021). Interstate Frequently Asked Questions. U.S. Department of Transportation.
[31] Wikipedia. (2021). National Highway System (United States).
[32] Federal Highway Administration. (2014). Highway Finance Data Collection. U.S. Department of Transportation.
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median strips. The Departments of Transportation and Agriculture could design the program jointly to consider both soil health and highway safety.

- The USDA develop a federal program to contract with farmers to produce the seed supply necessary for large-scale planting of medians.
- The administration institutes a federal policy to plant carbon-sequestering perennials alongside new and upgraded road and rail lines.

The administration could pursue these steps using discretionary funds allocated to the Department of Transportation to support competitive-grant programs for infrastructure. The administration could also leverage part of the $110 billion allocated in the bipartisan Infrastructure Investment and Jobs Act towards infrastructure upgrades, including upgrades focused on climate-change mitigation, resilience, and equity.

Contributors

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