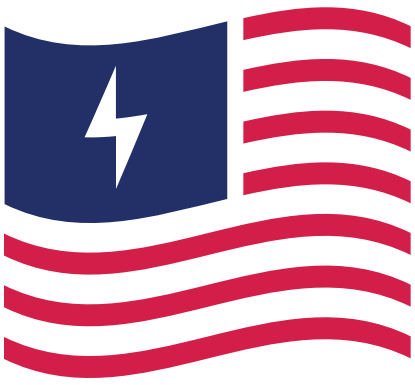

America's ZERO CARBON ACTION PLAN

The Zero Carbon Consortium

2020

5.5 Accelerating Sustainable Land Use Practices in the U.S.

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5.5.1 Introduction, Context, and Goals

While the focus of the Zero Carbon Action Plan (ZCAP) is on transformation in the energy, transport, and building sectors, achieving net-zero greenhouse gas (GHG) emissions for the United States by 2050 will require a concerted set of actions in land use. Infrastructure for renewable energy production and transmission will need to be sited, displacing some other productive uses. The energy sector modeling in chapter 2 shows that biofuels will be part of the energy mix by 2050, raising a number of sustainability challenges. Meanwhile, decarbonization will require reducing GHG emissions from agriculture and livestock, and managing soils to increase carbon storage. Reforestation and afforestation, together with best practices in forest management, can increase the carbon sink in U.S. forests significantly. Pressures on land use can be reduced if the population moves towards healthy, low-carbon diets, and if food loss and waste is reduced.

It is important to emphasize that sustainable land use management does not only strive to minimize GHG emissions. Land use must also accommodate urban areas and infrastructure, meet national commitments to water and biodiversity conservation and maintenance of ecosystem functions (including reduction of local pollutants to benefit human and ecosystem health), and provide enough food to satisfy human needs for the United States and the global food trade. The Food, Agriculture, Biodiversity, Land Use & Energy (FABLE) Consortium is developing a set of sustainable land use pathways for the United States to 2050 that optimize trade-offs between production (including food and biofuels), conservation, and GHG targets by 2050.[1]

This chapter does not offer an exhaustive set of policy prescriptions covering all issues related to sustainable land use. Instead, we discuss available policy instruments that would move the country towards land uses embedded in the energy modeling in chapter 2 and the FABLE sustainable pathways. Our focus, then, will be on challenges in siting renewable energy infrastructure and achieving the negative emissions in the land sector assumed by the energy sector pathway, while also satisfying the constraints imposed by the FABLE modeling exercise in terms of forest expansion, dietary changes, and reduction in food loss and waste. As the current state of the FABLE modeling does not cover reduction in emissions through nitrogen management or better livestock management, we do not consider them in this chapter, but point the reader to resources such as those from the U.S. Department of Agriculture (USDA).[2]

i We thank Peter Lehner (Earth Justice), Ritwick Ghosh (NYU) and Sonali McDermid (NYU) for their review of this chapter.

5.5.2 Siting Renewable Energy Infrastructure

As an example of the scale of the renewable energy siting challenge, chapter 2 examines pathways to achieve mid-century net-zero emissions from the energy and industrial sectors in the U.S., and finds that land area on the scale of Vermont plus New Hampshire will be needed for ground-mounted, utility-scale solar photovoltaic (PV) installations (or approx 1485 gigawatts), assuming a *central scenario* with lower fuel prices; this draws on the modeling work of "Spatial Planning for a Low-Carbon Future".[3] Total onshore wind installations needed to meet the model's GHG emissions targets under the same scenario assumptions will require land the size of New Mexico[ii] (or approx 990 GW).[4] Siting renewable energy facilities of this magnitude suggests that policies will need to address several key issues:

- Siting barriers due to environmental and social impacts pose increasingly important challenges for cost-effective and rapid renewable energy deployment.
- Environmental and land use impacts due to large-scale renewable energy development may be significant if they are unaccounted for.
- Both long distance and interconnection transmission corridors will be essential for achieving low-impact, cost-effective, and rapid renewable energy development, but transmission—particularly interstate transmission—historically has been difficult to site and permit. Interstate transmission is regulated by the Federal Energy Regulatory Commission (FERC), while local jurisdictions maintain responsibility for local siting. This split responsibility poses challenges for interstate transmission siting, due to divergent priorities regarding energy security and environmental concerns.

Policies need to address these considerations in an integrated manner by framing transparent siting processes and financing mechanisms for RDD&D, project development, and host community impacts.

Facilities Siting Processes

Integrated Planning

Policies at all levels should integrate land use siting constraints and impacts in low-carbon energy planning processes. A low-carbon energy planning framework that integrates land use and spatial considerations can directly address siting constraints as a key barrier to rapid and large-scale renewable energy deployment. Land-energy integration allows planners and policymakers to identify development opportunities that avoid downstream conflicts such as lengthy project delays or cancellations, negative ecological impacts, and backlash against renewable energy development by local communities leading to outright development bans. By incorporating conservation data into long-term energy planning, it is possible to establish the protection of natural lands and conservation as an objective of long-term energy planning. At the federal level, policies should mandate development of integrated spatial planning for interstate projects, as well as at state and local levels. These policies should include defined timelines for creation of such integrated plans in order to enable collaboration throughout the siting process, promote effective financial planning for renewable infrastructure investments, and avoid lock-in of infrastructure that may pose long-term, negative ecological consequences.

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ii Calculated using average land use factors, corresponding to the low fuel price scenarios.

Integrated land-energy planning also can help identify development strategies that address unavoidable anticipated impacts. For example, some of the best areas for wind power in the U.S. are located in the Great Plains, 80 percent of which is cropland, pastureland, or rangeland. And cropland—being sunny, flat, and accessible—is an ideal location for solar farms. Integrating wind and solar energy into agricultural landscapes in synergistic ways can spur needed economic development in rural communities while avoiding both conflicts over farmland conversion and natural habitat conversion and fragmentation. At the same time, addressing concerns over loss of cropland displaced by solar and wind requires a policy process that identifies win-win opportunities and balances trade-offs. How planners and policymakers manage the land use transition that must accompany a low-carbon transition can shape the perception of renewable energy infrastructure as either a threat or an opportunity. Inter-agency collaboration is needed to produce holistic environmental and social risk maps for energy modeling to help with both planning and siting of renewable energy facilities.

American Farmland Trust's Smart Solar Siting Partnership Project for New England offers some elements that could be incorporated into such integrated federal policy.[5] The project aims to accelerate expansion of solar energy while maintaining productive, resilient farmland and forest land by building an ongoing, multi-stakeholder coalition to advance smart solar siting policies and programs in New England states. Creation of a federally organized multi-stakeholder task force to advance renewables siting across the U.S. would provide a transparent structure to promote efficient siting decisions that incorporate local considerations. A federal policy that promotes dual goals of solar facility siting and farmland preservation can mitigate conflicts between land use, food systems, and decarbonized electricity production. Such a policy should include incentives that prioritize solar development on existing structures on agricultural land, as well as dual use arrays ("agrivoltaics") co-located with agriculture and livestock.

The Accelerated Renewable Energy Growth and Community Benefit Act, passed by the New York State legislature in April 2020, is another model for federal legislation to advance decarbonization while promoting sustainable land use.[6] For example, the Act authorizes the New York State Energy Research and Development Authority's (NYSERDA) Clean Energy Resources Development and Incentives Program to rapidly advance new "Build-Ready" projects and prioritize development of renewables projects on existing or abandoned commercial sites, brownfields, landfills, and otherwise underutilized sites.[7] Some examples include road medians, sand and gravel pits, industrial sites, and correctional facilities. This initiative also can be replicated and supported at the federal level.

Siting on Federal Lands

In addition to policies that facilitate siting on contaminated or underutilized lands, transparent, well-defined policies should enable renewable energy facility siting on federal lands while accounting for and addressing environmental effects. Federal policies should establish content and timing parameters for environmental impact assessments for siting of renewable energy facilities. Such parameters will promote consideration of land use trade-offs, transparency regarding challenges and their potential impacts, and timelines that can foster efficient and effective siting decisions. Federal policies should require local governments to make decisions on renewables facility siting in writing within a specified period of time.[8]

Since energy infrastructure for both generation and transmission involves long-term investments, integrated land-energy planning helps avoid long-term infrastructure lock-ins that lead to undesirable ecological outcomes. By identifying low-impact, high quality areas for wind and solar development, it is possible to coordinate the early planning of the transmission network needed to interconnect new low-impact renewable energy power plants to the grid.

Financing Mechanisms

Policies should include support for research on and promotion of small-scale siting and distributed generation, which can avoid some of the environmental and land use trade-offs associated with siting of large-scale renewables and transmission infrastructure. As previously mentioned, agrivoltaics offer an opportunity to co-locate small-scale renewable energy technologies with agricultural development, providing complementary benefits to food production, irrigation water requirements, and carbon-free energy production. Policies should include financing incentives to aid agricultural land owners with upfront costs of installing renewables such as solar PV on their properties. Several grant and loan programs already exist. For example, the Business Energy Investment Tax Credit, revised most recently in 2018, offers tax credits to eligible sectors, including the agricultural sector, for solar water heat, solar space heat, geothermal electric, solar thermal electric, solar thermal process heat, solar photovoltaics, wind, geothermal heat pumps, municipal solid waste, combined heat & power (CHP), tidal, wind, geothermal direct-use, fuel cells using renewable or non-renewable fuels, and microturbines. Expiration dates for tax credits for these technologies vary by technology and project start date. A framing policy is needed to expand and ensure longevity of this program to promote decarbonization goals.

Established in 2003, the U.S. Department of Agriculture's (USDA) Rural Energy for America Program (REAP) offers another example of an existing federal financing mechanism that can promote agrivoltaics by mitigating upfront installation costs. REAP provides financial assistance to agricultural producers and rural small businesses to:

- purchase, install and construct renewable energy systems, including small and large scale solar and wind, biomass, geothermal, hydrogen, small hydropower (less than 30 MW), and ocean/tidal technologies;
- make energy efficiency improvements to non-residential buildings and facilities;
- use renewable technologies that reduce energy consumption, including switching to electrically powered sprinklers and irrigation systems; and
- participate in energy audits & renewable energy development assistance.[9]

The grants for renewable energy systems, which can cover up to 25 percent of total eligible project costs, range from $2,500-$500,000. Loan guarantees, alone or in combination with grant funding, can cover loans up to 75 percent of total eligible project costs. The 2014 Farm Bill established a permanent funding baseline of $50 million per year for the program, reaffirmed in the 2018 Farm Bill. This program appears to be underutilized, based on an announcement from USDA in July 2019, which solicited applications and noted $400 million still remaining of its $565 million FY2019 budget.[10] The program would benefit from federal-state coordination to disseminate information to potential applicants, and it should be linked to other long-term policy initiatives to promote its use and longevity.

Transmission Siting

To support new renewables facilities, policies should address related transmission siting. Facilitating zoning of large-scale renewable energy development can help streamline transmission and generation planning and enable low-cost, low-impact renewable energy development. Despite the vast land area a low-carbon transition will require, it is possible to meet low-carbon electricity goals with minimal conservation and land use impacts. Studies show that sharing renewable energy resources across states can significantly reduce costs of achieving ambitious climate targets while also meeting land conservation goals.[11] Yet, regional energy solutions depend on early and proactive transmission planning. Interstate transmission lines will be needed to transmit low-impact, high quality renewable electricity to demand centers, yet interstate transmission lines take 10 or more years to permit and construct. We must begin planning essential transmission corridors now. Revising zoning regulations could include pre-approving permits for low impact sites, reducing land costs, and preemptively planning transmission for development on low-impact public sites, and expediting permitting of transmission upgrades or development of new lines on existing right-of-ways.

Regulations also must address jurisdictional overlaps among state and federal governments, regional transmission operators (RTOs), and the ability of one or a few states to veto an interstate expansion to balance regional and local interests. The Federal Government can establish RTOs and rule on interstate transmission disputes.

New York's legislation provides several models for policies to promote timely, cost-effective transmission siting that account for land use considerations. The Accelerated Renewable Energy Growth and Community Benefit Act creates a State Power Grid Study and Investment Program to identify investments in distribution and local and bulk transmission necessary to meet the State's requirements under the Climate Leadership and Community Protection Act. It also authorizes an expedited permitting process for transmission projects that are planned for existing rights-of-way. Federal policies should support this regional and local focus on transmission projects needed to support addition of renewables to the grid.

Where an economic incentive structure is not in place, policies must drive further transmission build-out. Such policies include federal regulations that fairly allocate costs for long distance transmission lines. A precedent for federal policy incentivizing transmission for renewable power delivery already exists. Section 1222 of the 2005 Energy Policy Act (42 U.S.C. 16421) enables the Federal Government to utilize non-federal funding to expand transmission infrastructure for delivery of power from renewables. It authorizes the Secretary of Energy, acting through the Southwestern Power Administration or the Western Area Power Administration, to "design, develop, construct, operate, own, or participate with other entities in designing, developing, constructing, operating, maintaining, or owning two types of projects".[12] The two project categories are "(1) electric power transmission facilities and related facilities needed to upgrade existing transmission facilities owned by Southwestern or Western (42 U.S.C 16421(a)), or (2) new electric power transmission facilities and related facilities located within any State in which Southwestern or Western operates (42 U.S.C. 16421(b))".[13] The policy specifically allows the Secretary of Energy to "accept and use funds contributed by another entity for the purpose of executing the Project (42 U.S.C 16421 (c))".[14] This policy thus enables partnerships between the Federal Government and private entities to finance and develop siting of transmission lines even without support from state utility commissions.[15]

The Federal Government has utilized Section 1222 only once since enactment of the Energy Policy Act of 2005; in 2016, for a partnership with Clean Line's Plains & Eastern Clean Line Project to develop transmission facilities from Oklahoma to the Arkansas-Tennessee border. Both parties terminated the agreement in 2018, eliminating federal funding for the project. To promote public-private partnerships on transmission siting to enable delivery of electricity from renewables, particularly from those sited in sparsely populated areas to areas of high electricity demand, the Department of Energy should develop new requests for proposals for new or upgraded transmission line projects under Section 1222. To promote effective implementation of such proposals, Section 1222 must be coupled with a transparent environmental impact assessment process and timeline to enable these public-private partnerships to accurately calculate costs and time for project development, as well as consideration of environmental effects associated with siting. Further, expansion of Section 1222 to include Bonneville and Southeastern Power Administrations would enable public-private partnerships to support transmission siting for renewables installation in Bonneville's territory, which includes Idaho, Oregon, Washington, California, Nevada, Utah, Wyoming, and parts of Montana, as well as Southeastern's territory, which includes West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, and Kentucky.

Moving beyond policies such as Section 1222, federal policies should facilitate conversion of existing high-voltage alternating current (HVAC) transmission lines to high-voltage direct current (HVDC) lines. The Energy Information Administration used ICF to assess the potential for such conversion in a June 2018 report.[16] The report found that HVDC conversion can facilitate cost-effective movement of energy output from remotely located renewables to distant load centers.[17] By increasing the capacity of existing transmission corridors, such conversion would enable addition of renewables to the existing grid while reducing the need for new transmission lines, thus mitigating land use issues associated with transmission expansion. Policies should include support for RDD&D to address the technical challenges of HVAC to HVDC conversion, including control of power flow between terminals, construction of HVDC circuit breakers, and intermittency uncertainties.[18]

Addressing Impacted Communities

Without appropriate policies in place, energy projects sited in socially disadvantaged communities can impose long-term, negative environmental effects on these communities. Examples such as the Dakota Access Pipeline siting process and the more recent cancellation of the Atlantic Coast Pipeline highlight the need to incorporate community engagement formally into siting of energy facilities, including renewables. To avoid such effects and prevent social backlash, policies are needed to create frameworks that engage impacted communities in the siting process and decisions on compensation. Such policies and frameworks should:

- Enable regional planning (at the level of Western Interconnection, for example) to improve planning outcomes. Such planning should promote interstate and interagency coordination, including electricity demand modeling.
- Promote siting of clean energy technologies on already disturbed, degraded, or contaminated land, including brownfields. The National Renewable Energy Laboratory estimates that about 2,000 GW of solar PV potential exists on 20 million acres of landfills and other contaminated or disturbed sites.[19] This area exceeds the total land area of Vermont and New Hampshire combined, which amounts to approximately 12 million acres.

- Wind developers should utilize the U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines and best available science to identify appropriate measures to reduce impacts of development and operation.[20]

New York's legislation (Accelerated Renewable Energy Growth and Community Benefit Act) provides several models for policies to address communities impacted by renewables siting,[21] including:

Centralized, transparent siting decisions with community input: The Office of Renewable Energy Siting established under the Act will provide a centralized forum to promote predictability and timeliness of siting decisions, including opportunities for input from local communities. The Act requires all new, large-scale renewable energy projects of 25 megawatts (MW) or larger to seek a permit through the new office. The Act also requires all siting applications to provide proof of consultation with host communities regarding procedural and substantive requirements of applicable local laws. The permitting and pre-construction processes thus must engage landowners and local authorities. The new office must act on complete applications within one year, with a six-month deadline for certain former commercial and industrial sites. The Act stipulates that absence of a determination within the required timeframe will result in de facto approval of the draft permit and granting of a permit.

Efficient, effective environmental reviews: The new office will facilitate efficient timing and improve the effectiveness of environmental reviews of large renewable energy facilities by establishing regulations and uniform standards for environmental impacts common to large, renewable energy projects. The office will also identify mitigation measures to address these impacts.

Wildlife conservation: To protect wildlife from siting effects, the office will require that "uniform and site-specific standards and conditions shall achieve a net conservation benefit to any impacted endangered and threatened species".[22] The Act also establishes an endangered and threatened species mitigation bank fund to finance projects that facilitate such a "net conservation benefit to endangered and threatened species potentially impacted by a major renewable energy facility".[23]

Host community economic benefits: New York's legislation establishes mechanisms to provide incentives to property owners and communities that host major renewable energy facilities. The Act also tasks NYSERDA with assessing the need for green workforce training in host communities, with a particular focus on environmental justice. NYSERDA must create one or more job training programs based on its assessment.

This combination of regulations and financing mechanisms for community engagement can be replicated and supported at the federal level, particularly for facilities sited on federal lands. Such federal measures should include streamlined, transparent environmental impact assessments with defined timelines, as well as established funding mechanisms to address effects on endangered and threatened species. Federal policies should provide incentives for host communities, particularly when the facilities are providing interstate power. Policies also should require localities and states to create transparent processes for input from host communities. Finally, federal policies can allocate funding for green workforce training in host communities, and they should provide models and guidelines for such training programs.

5.5.3 Promoting Reforestation

The White House's United States Mid-Century Strategy for Deep Decarbonization suggests that 20 to 40 million ha of reforestation is needed to meet the land sector's contribution towards the goal of 80 percent reduction of GHG emissions below 1990 levels by 2050.[24] The report indicates that 40 million hectares (mHa) is equivalent to about one-third of 1850 U.S. forest cover. Other studies have shown a potential of over 60 mHa of reforestation.[25] Reforestation is defined as conversion from non-forest (<25 percent tree cover) to forest (>25 percent tree cover). Reforestation will occur on lands labeled 'natural ecosystems' which used to have trees.[26] Meeting a 40 mHa reforestation goal by 2050 implies approximately 1.3 mHa of forest need to be planted annually, which would sequester about 1.77 TG/ha/yr[iii] of CO_2 equivalent or a total of 53.2 Tg CO_2 equivalent over 30 years. Carbon removal benefits depend on geographic location and species planted.

Given that two-thirds of U.S. forest land is currently privately owned, most reforestation will likely occur on private lands. Private landowners will need incentives to reforest their land, and compensation for costs of reforestation including site preparation, planting material, labor, and maintenance for the first few years (an average cost of $900 per hectare).[iv]

The following recommendations can set the groundwork for an ambitious reforestation strategy to 2050:

Congress should mandate the development of a strategy to achieve a national reforestation goal by 2050. This will involve not only a spatially explicit plan mapping out potential areas of reforestation, but also quantifying the carbon removal benefits by location. This can build on existing management plans by the Bureau of Land Management (BLM) and the Forest Service, by reforming them to explicitly prioritize climate and reforestation. In addition, research will be needed to design optimal policies, in particular on the design of incentive payments to landowners. Payments need to be sufficient to cover opportunity costs, reforestation costs, and recurring costs conditional on a forest left standing. The recurring costs must be cost-effective in terms of the gains in carbon sequestration, perhaps dynamic to account for varying carbon sequestration rates in a forest over time, and designed to avoid perverse incentives (such as deforestation in order to capture future reforestation benefits). This research could be embedded in a broader effort to study the right amounts and structure of payments for ecosystem services across the U.S. Monitoring mechanisms to ensure compliance will also have to be developed. State governments should also articulate reforestation plans and policies to meet a national goal by 2050.

Where possible, the government can avoid the issue of annual incentive payments, monitoring, and enforcement by expanding the national forests by acquiring and reforesting private lands, as has been done before, or authorizing transfer of Bureau of Land Management (BLM) lands to the Forest System[v]. In the face of climate change, Congress could authorize the purchase of lands (and lesser property interests, such as conservation easements) specifically to strengthen the negative emissions provided by forests, as well as high quality grasslands. These purchases should be guided by credible scientific life cycle assessments that include externalities.

iii Mean sequestration rate of 1.33 Mg C ha-1 yr-1.

iv Range $1.62b @ $600/ha to $2.97b @ $1,100/ha. Costs vary by region, species, and planting density.

v During the 1920s-1930s, the Federal Government used purchase authority under the National Industrial Recovery Act of 1933, the Emergency Relief Appropriation Act of 1935, and the Weeks Forestry Act of 1911 to purchase land rendered economically unproductive. Much of that land has since been restored and reforested (see Cheever et al. 2019).

To reduce concerns over taking productive lands out of local economies, and to heighten the likelihood of political palatability, Congress might focus these efforts on lands rendered economically unproductive by the effects of climate change, such as expanded floodplains, fires, and drought, as well as the retreat of northern permafrost in Alaska. Whether incorporated into the National Forest System or managed under the supervision of farm bill programs, such steps might be a boon to farmers eking crops out of marginal lands or considering farm transfers where children are not interested in continuing the family business.[27] State and local governments can also consider acquisition of land as part of a national reforestation policy goal.

Where outright acquisition is infeasible, Congress could create or extend existing conservation easement programs. Easement programs under the Forest Legacy Program, Migratory Bird Conservation Act, agriculture bills, and the Safe Drinking Water Act have offered much-needed supplemental income to landowners. They could also be targeted to places that show high forest carbon sequestration potential. Moreover, where servient landowners retain an interest, there exists a constituency for continued public appropriations to sustain a program.[28] The same program should be explored at state level.

Alternatively, landowners could be compensated for upfront reforestation costs and maintenance costs through incentives and subsidies. Four main sources of potential funding through existing programs include federal cost share programs, federal tax programs, state and local programs, and forest carbon programs.

Cost share programs under the Farm Bill

Numerous forest-related cost-share programs are administered by the Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA). Most of these originated in the farm bill, and although most are focused on agriculture some address forest conservation. None explicitly target reforestation or carbon sequestration goals. Programs include:

- EQIP: Environmental Quality Incentives Program
- CSP: Conservation Stewardship Program
- EFRP: Emergency Forest Restoration Program
- HFRP: Healthy Forests Reserve Program
- CRP: Conservation Reserve Program
- CREP: Conservation Reserve Enhancement Program
- FLP: Forest Legacy Program
- ACEP: Agricultural Conservation Easement Program

In addition, a handful of states administer state-level programs that encourage reforestation, for example the Virginia Reforestation of Timberlands program.

Each of these programs have different objectives and payment schemes. Some are one-time payments and others are annual (rental) payments for a specified number of years. Some cover only establishment costs and others cover maintenance costs. These programs are administered by state agencies and/or Federal agencies such as NRCS or FSA. Further increases are needed in their funding and staffing to meet an ambitious national reforestation goal.

A new, dedicated reforestation cost share program would play a key role in achieving 40 mHa of reforestation by 2050. Most of the programs mentioned above pay landowners on a per acre basis, but reforestation schemes can be developed that pay landowners for trees planted volume, tons of CO_2 sequestered, or pay-for-performance programs.

Federal Tax incentives

Various federal tax incentives are available for active forest management. The primary one is the Reforestation Tax Incentive Program, which provides up to a $10,000 per year deduction and any additional amount over $10,000 per year may be amortized over 84 months. Other Federal programs that may provide indirect tax incentives for landowners include:

- Cost Share exclusions - payments from government cost share programs
- Casualty loss provisions - indirect payments from disasters and other casualty losses
- Donating a conservation easement
- Estate planning strategies such as marital deduction, special use valuation, trusts, and more[vi]

In order to meet the target of 40 mHa of reforestation by 2050, better tax incentives should be implemented. For example, the current reforestation tax deduction could be changed to a tax credit, and the amount of credit increased. There are various ways the Treasury can allocate tax credit rates to meet these goals.

State and local level programs

State and local programs such as green growth policies, property tax incentives, zoning regulations, hunting and fishing licenses, and technical assistance for landowners can incentivize reforestation.

Property tax incentives, in particular, can serve to promote reforestation, if designed correctly. Every state provides in one way or another a preferential property tax to farm and forest land. These programs provide a deduction to the assessed fair market values of a property. Preferential assessed values vary by state and range from full or partial exemptions to percentage deductions or flat rates to current use valuation approaches. The intention of most of these programs is to encourage retention of open space and conservation of these lands from being developed. Programs could be enhanced to offer specific incentives for planting trees.

Forest carbon programs

Forest carbon programs are market-based approaches mainly implemented by non-governmental environmental and forestry organizations and associations. These programs incentivize private forest landowners to practice sustainable forestry and provide them payments for the amount of carbon sequestered from the land. Typically programs aggregate groups of private landowners to sign up. Carbon credits are verified and sold to companies willing to purchase the carbon credits as offsets.

In addition to reforestation, it is well-understood that improved forest management could increase carbon sequestration in U.S. forests. Importantly, any federal or state subsidies for harvesting trees should be eliminated in order to capture sequestration benefits of continued forest growth.

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vi See, for example, Estate Planning for Forest Landowners.

In order to allow the Forest Service to manage the National Forest System to sequester more carbon and encourage more resilience in the face of climate-driven disturbance, Congress should reduce the drain that wildfire suppression has placed in the Forest Service budget. To solve the problem, Congress should change the way the government of the United States pays for wildfire control. Instead of treating wildfire as an agency expense draining money away from forest management and land purchase, wildfires should be treated like other natural disasters—caused by climate change or not—and financed out of general funds. The Wildfire Disaster Funding Act, which provides a mechanism for achieving this goal, has been introduced in Congress.[29]

5.5.4 Increasing Soil Carbon Storage

Increasing the storage of carbon in agricultural soils could make a very significant contribution to U.S. deep decarbonization goals. One strategy alone—growing cover crops on the 40 percent of land used for the top five primary crops in the U.S. not already using them (88 million out of 230 million acres)—could store additional carbon equivalent to 100 million tons CO_2 per year at minimal cost.[30] Other measures include conservation tillage, efficient irrigation, sustainable grazing and improved nutrient management. Chapter 2 projects that the land sink needs to store 375 Mt CO_2 equivalent per year by 2050 to achieve economy-wide carbon neutrality, assuming net-zero emissions in the energy and industrial sectors. Using the FABLE sustainable pathway, 347 $MtCO_2e$ of that sequestration can come from ambitious reforestation, dietary shifts, changes in international trade of agricultural and forestry commodities, and agricultural productivity improvements, which leaves around 27 $MtCO_2e$ to be achieved through other land-based climate solutions not modeled in the FABLE pathways, including improved forest management and soil carbon sequestration. This would be a minimum target estimate for soil carbon (SOC) sequestration, as the FABLE pathway assumes ambitious changes across the food and land use sectors. Consequently, policy measures devoted to stimulating increased soil carbon storage should be an important plank of U.S. climate policy.

Policy in this area should be built around four pillars:

Pillar 1. Monitoring, reporting and verification (MRV): A key barrier to implementing programs to increase soil carbon at large scale is the need for credible and reliable monitoring, reporting, and verification (MRV) platforms, both for national reporting and for emissions trading. Without such platforms, investments could be considered risky.[31] While the modeling and measurement tools to enable such a platform exist, considerable funding is necessary to overcome high initialization costs and unequal monitoring capacity. Assuming $20-$50 for MRV from previous estimates derived from forestry projects over 410 million acres of U.S. agricultural land, we estimate the costs of an MRV program at $250-$650 million per year.[32] Costs would likely come down as MRV protocols are standardized and more cost-efficient monitoring technologies are developed and rolled out, a key research priority for the newly established Advanced Research Projects Agency (ARPA) Land, described in Section 5.5.8.

This platform should consist of a system of benchmark sites for long- and short-term soil carbon monitoring, representing a wide range of land use types, soil types, and management practices, supplemented by models of soil carbon change that can also simulate a range of scenarios of future change. If the models are deemed reliable, they could be used to derive region-specific emission or soil carbon stock change factors, or directly simulate regionally-disaggregated soil carbon change and GHG emissions.

Funding for these activities should also be made available to developing countries, including capacity building and technology transfer, given the high soil carbon storage potential in countries in Southeast Asia and Eastern Europe.[33]

Pillars 2 and 3, extension and financing, respond to the large transaction costs that farmers face to learn, invest, and durably adopt management practices and technologies that enhance soil carbon storage.

Pillar 2. Financing: Federal environment and conservation programs need to be expanded significantly to incentivize farmers to durably adopt a range of management practices that will enhance soil carbon storage. This includes increasing the annual budget of the US Department of Agriculture's Conservation Stewardship Program (CSP) from $1 billion to $5 billion. CSP provides financial assistance to farmers meeting threshold levels of conservation on their entire farm through a five-year contract. In return for annual payments, the producer agrees to maintain current conservation practices and increase or improve conservation across the farm during the five years of the contract. Another incentive measure that should be implemented is federal crop insurance reform, tying insurance premiums to the carbon intensity of farm management practices implemented; premiums would be reduced if carbon storage practices are adopted, while carbon intensive practices would increase premiums given the increased climate risk associated with their use. Similarly, building on the USDA's Sodbuster and Swampbuster programs, a suite of existing agricultural subsidies should be made conditional on the adoption of a range of management practices and technologies, akin to what is already done in the European Union.[34]

Pillar 3. Extension: In tandem with increased financial incentives, significant investments need to be made in the agricultural extension workforce, to increase the number of experts on the ground that can help farmers learn about, adopt, and adapt different management practices and technologies to enhance carbon storage, tailored to their unique environment. As a result, we recommend almost tripling the USDA NRCS staff capacity from 12,000 to 30,000, in line with Governor Inslee's Growing Rural Prosperity plan, which we estimate would cost approximately $1.5 billion per year. In addition, and in line with the 2020 Agriculture Resilience Act, we recommend setting aside 1 percent of Farm Bill conservation program funding to finance third party extension programs in conservation districts, land-grant universities, NGOs, and land trusts.

Pillar 4. Public-private partnerships: As explored in chapter 5.6, the Environmental Protection Agency's (EPA) Sustainable Materials Management (SMM) program fosters partnerships to reduce food waste in corporate supply chains and federal agency operations by supporting public-private partnerships to increase the recycling of food waste as agricultural soil amendments to stimulate soil carbon storage. If expanded and supported, this could have the co-benefit of reducing methane emissions from food waste decomposition in landfills.

5.5.5 Next Generation Biofuels

While the light-duty vehicle fleet will be largely electrified by 2035, biofuels will play an increasingly important role in other transport sub-sectors, including heavy-duty vehicles, aviation, and shipping. Chapter 2 projects that second generation biofuels, such as miscanthus (180 million tons) and switchgrass (135 million tons), will make up over 80 percent of biofuel production in the U.S. by 2050. This corresponds to approximately 4 million barrels of biofuel production per day, four times the current rate of fuel ethanol production and 10-20 percent of current U.S. petroleum refining capacity. We note that producing these crops for biofuels does not imply expanding cropland; the FABLE sustainable land use pathway shows that with dietary changes and productivity increases, these crops can be grown on land previously used for growing livestock feed.[35] We envisage a three-pronged approach to sparking this transformation: increased RDD&D funding, a new low-carbon fuel standard, and new federal procurement standards.

RDD&D funding: A central funding priority of the newly established ARPA-Land (as described in Section 5.5.8) should be the research, development, demonstration, and commercialization of next generation biofuels, particularly biofuels made from non-food (cellulosic and algae-based) resources. Funding should be made available for both private and public (including state research institutions) research initiatives via ARPA-Land, including competitive grant and cost-sharing programs. Increased private-sector RDD&D will also be stimulated by the strong market signal sent by a new low-carbon fuel standard, described below.

Low-carbon fuel standard: Post 2022, the Renewable Fuels Standard should be transformed into a low-carbon fuel standard that promotes low-carbon biofuels for vehicles that cannot be electrified cost-effectively, as well as planes and ships. This policy mechanism would support the ZCAP projections of increased miscanthus and switchgrass use as biofuel feedstocks by 2050. The new standard should set a technology- and feedstock-neutral benchmark for liquid and non-liquid fuels, tied to a lifecycle assessment of the carbon intensity of the fuels which takes into account land use implications. The carbon intensity standard should become more stringent over time—at least 80 percent below gasoline and diesel—and include guardrails to prevent conversion of non-agricultural lands into cropland, particularly sensitive lands with high carbon sequestration and biodiversity value.[36] The new standard should reward entities in the value chain, including farmers and producers, that use climate-smart practices that reduce carbon emissions, store soil carbon, and reduce nitrous oxide emissions, coordinating with policy efforts to improve farm-level management practices.[37]

Federal procurement standards: In order to rapidly ramp up demand for next generation biofuels, the Federal Government should use its authority under existing legislation, such as the Defense Production Act, to direct the USDA, Department of Defense, and other relevant departments to procure increasing levels of advanced low-carbon renewable fuels. From 2013-2017 the Department of Defense alone consumed approximately 90 million barrels of fuel per year, underlining the potential importance of a focused federal procurement strategy in changing market demand for next generation biofuels.[38]

5.5.6 Support Healthy Low-Carbon Diets

Pastureland dedicated to producing meat, especially beef, and cropland for animal feed together consume over 40 percent of land in the continental US. Integrated modeling suggests that dietary shifts are key to achieving net-zero GHG emissions in the land use sector by mid-century.[39] The U.S. FABLE sustainable land use pathway assumes that the American diet transitions towards a "healthy US-style pattern" as determined by the Dietary Guidelines for Americans by the USDA.[40] Compared to the EAT-LANCET recommendations, red meat, pork, milk, oils and fats, poultry, sugar, eggs, and animal fats are over-consumed in the current diet while cereals, fish, fruits and vegetables, pulses, and nuts are under-consumed. Moreover, fat intake per capita exceeds the dietary reference intake (DRI) due to high consumption of oils and fats and animals fats. Importantly, a diet that is more environmentally sustainable than the average U.S. diet can be achieved without excluding any food groups.

Several proven interventions can impact food preferences in order to foster a dietary shift towards a food system with lower GHG emissions.[41] The Federal Government can promote the shift with the following policies:

- Health and Human Services (HHS), in partnership with USDA, should ensure that dietary guidelines for Americans not only reflect the latest nutrition science, but also incorporate sustainability.[42] The Scientific Report of the 2015 Dietary Guidelines Advisory Committee already recommended incorporating sustainability into dietary recommendation guidelines. In 2021, HHS should take the next step and formally incorporate sustainability into the dietary guidelines for Americans.
- USDA should foster climate-friendly certification to encourage low-carbon agriculture and livestock production, following the success of organic certification in creating a price premium for organic products.
- Nutrition standards for food and beverages in schools have been shown to benefit diet and weight.[43] USDA should maintain the nutrition standards of school meals that were in effect prior to USDA's interim final rule from November 2017, as well as current nutrition standards for school snacks. The USDA should align food nutrition standards for child nutrition programs (The Child and Adult Care Food Program (CACFP), The National School Lunch program, The School Breakfast Program, The Summer Food Service Program, The Fresh Fruit and Vegetable Program, and The Farm to School Program) with updated dietary guidelines for Americans that incorporate sustainability. In particular, child nutrition programs should increase the proportion of plant-based meat alternatives, fruits and vegetables in meals.
- USDA should continue to implement the Community Eligibility Provision that allows schools in high-poverty areas to serve free meals to all students, regardless of income. These meals should satisfy nutrition and low-carbon standards.
- Change the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) to include additional healthy foods, including more fish; increasing whole grains, fruits, and vegetables; and reducing sodium and saturated fat.[44] This has been shown to lead to healthier food purchases and intake by families using WIC.[45] WIC's Farmer's Market Nutrition Program provides fresh, locally-grown produce to participants and has been proven to increase fresh fruit and vegetable consumption.[46]
- Provide SNAP (Supplemental Nutrition Assistance Program) incentives for vegetables and fruits.[47] The Healthy Incentives Pilot in 2013 showed that certain SNAP recipients were successfully incentivized to purchase more fruits and vegetables.[48] SNAP-Ed,

educational programs that encourage participants to make healthy food choices, have been found to increase fruit and vegetable consumption among elementary school children and seniors in the program.[49] Successful Healthy Incentive and SNAP-Ed programs should be scaled up and continuously evaluated to improve impact.

- USDA's Food Insecurity Nutrition Incentive (FINI) program incentivizes SNAP participants to buy more fresh produce by lowering the cost of nutritious foods. FINI grants should add sustainability to the criteria of foods eligible for subsidies for SNAP recipients, generating incentives for recipients to purchase low-carbon produce and plant-based meat alternatives.
- Congress should prioritize climate change in procurement contracts. The 2008 Farm Bill, for example, directed USDA to pass regulations encouraging institutions participating in child nutrition programs to purchase local agricultural products. Congress should pass legislation prioritizing low-carbon agricultural products for all government bodies, including large-scale purchasers such as the U.S. Department of Defense as well as hospitals and prisons.

State and local governments can promote a more sustainable food system by policies such as:

- SNAP incentives for farmer's markets such as New York City's "Health Bucks" program, which increases access to and purchase of vegetables and fruits in low-income communities.[50]
- Offer healthy foods on government property

5.5.7 Reducing Food Loss and Food Waste

A key part of reducing pressure on agriculture systems and meeting sustainability goals for land is to reduce food loss and waste. The USDA Economic Research Service estimates that 31 percent of food produced in 2010 was wasted at the consumer or retail levels.[51] EPA and USDA have set a goal of reducing food loss and waste by 50 percent by 2030, and over the next year should put forward specific policies at federal level or guidance to states in pursuit of that goal.

An important first step is to standardize measurement and data analysis tools to measure and monitor progress towards the goal of reducing food loss and waste.[52]

Policy interventions in this area include:[53]

- Government-backed loans for on-farm harvest storage facilities to reduce post-harvest food loss
- Create and deliver effective and consistent messaging to the public about the importance of food stewardship and the need to address food loss and waste
- Establish clear food sell- and use-by-date guidelines that distinguish between quality versus safety concerns
- Streamline procedures and rules for food donation from traders, processors, and retailers

- Follow the food waste hierarchy of (1) reduce the amount of food at the source, (2) feed excess food to people, (3) feed left-over food to animals, (4) compost what remains, and (5) anaerobically digest if necessary (e.g.,: mandate businesses and institutions recover/recycle food scraps, and mandate private haulers and management facilities to construct and maintain infrastructure to properly manage these materials)
- Reduce food discards and increase edible food redistribution in food wholesale, retail, and food services through ambitious reduction goals and actions, including tracking software and other tools (e.g., Leanpath) to reduce over-purchasing, avoidable food waste, and redirect edible food to local charities (target larger generators first)
- Require public reporting of food waste and recycling rates by private actors in the food sector
- Provide tax incentives for research and development on new technologies for reducing food waste
- Develop incentives for the recovery and recycling of food waste as animal feed or centralized composting

5.5.8 Conclusions and Policy Recommendations

In addition to the specific recommendations detailed above, we outline three overarching policy recommendations that span the many issues that arise with respect to decarbonization of the U.S. economy and the role of U.S. lands.

ARPA-Land: The ARPA labs have proven to be invaluable assets to U.S. leadership in scientific discovery and the development of cutting-edge technologies. The Defense Advanced Research Projects Agency (DARPA) has a $3.5 billion annual budget and since its creation has helped fund many world-leading combat vehicles and information systems. ARPA-Energy has invested $2 billion in government RDD&D investment since its first round of funding in 2009, financing a variety of energy projects and generating over 300 patents. Given the range of technical challenges the U.S. faces with regard to the role of its land in economy-wide decarbonization, the U.S. government should create an ARPA lab with a singular focus on land-based activities. Specifically, ARPA-Land should have the following funding priorities:

- Monitoring technologies and tools to measure soil carbon sequestration from short- (days) to long-term (decades) over small- (fields) to large-scale (continents) areas. Given the importance of soil carbon sequestration in the overall carbon budget, improvements in measurement and monitoring technologies will be critical.
- Next-generation biofuels that can achieve the low-carbon fuel goals outlined in this plan, particularly biofuels made from non-food (cellulosic and algae-based) resources.
- Next-generation, low-carbon intensity animal protein substitutes that can be made widespread at low-cost.
- Technologies for reducing food loss and waste, including innovations in food packaging, storage, and transport.
- Renewable energy technologies that minimally impact agricultural production when integrated with agricultural lands

New inter-agency task force on land: Inter-agency task forces have been established to address a variety of issues throughout U.S. history that require coordination of activities and regulatory approaches of multiple departments and agencies, ranging from human trafficking to climate change. At the start of the next presidential term, the administration should create a new inter-agency task force on land to coordinate the multiple issues relevant to U.S. lands in the context of deep decarbonization. Renewable infrastructure siting, increased soil carbon sequestration, biofuel production, reforestation, and shifting away from animal agriculture all have positive and negative (and likely competing) implications for land use change and land-based activities, and authority over each of these activities is spread across several areas of the U.S. government, including the Department of Defense, Department of Energy, Department of the Interior, Department of Agriculture, and the Environmental Protection Agency. To minimize competition for land, whether it be for food, fiber, or energy, it is critical that federal departments and agencies coordinate and align their priorities to manage trade-offs and maximize synergies in land use decisions. Moreover, such a task-force should coordinate with relevant states, as state governments also have significant authority over land use decisions.

Integrated Spatial Planning: The U.S. needs to invest in developing targets and long-term pathways towards sustainable land use and food systems that consider agronomy, nutrition, ecology, hydrology, climatology, economics, infrastructure engineering, the social sciences, and of course local politics. To our knowledge, the federal and state governments lack both long-term targets to achieve sustainable food and land use systems as well as pathways (i.e., sets of policies, management strategies, and programs) to achieve those targets. An important first step is to support the development of analytical tools to understand the complex synergies and trade-offs across these areas and to determine which short-term measures must be undertaken in order to achieve long-term objectives. Just as it is impossible to design and implement economic policies without sound macroeconomic models, the U.S. will not be able to make its land use and food systems sustainable without robust tools to model the integrated impacts of policies.

Taken together, these policy recommendations would mark a transformative step forward in ensuring a meaningful, positive contribution of the land use sector—in all its forms—to deep decarbonization in the U.S. Moreover, the many links between land use and other environmental crises—from air and water pollution to biodiversity loss—means that ambitious action in this sector will enable the U.S. and the world to improve multiple elements of human and ecosystem wellbeing.

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The **Zero Carbon Action Plan (ZCAP)** is a publication of the Sustainable Development Solutions Network. The Zero Carbon Action Plan (ZCAP) comprises multiple sector groups, convened under the auspices of the Sustainable Development Solutions Network United States chapter (SDSN USA). The report was jointly prepared by the Zero Carbon Consortium Chairs and members organized across several working groups.