118TH CONGRESS
1ST SESSION

S. 2812

To support carbon dioxide removal research and development, and for other purposes.

IN THE SENATE OF THE UNITED STATES

SEPTEMBER 14, 2023

Mr. SCHATZ (for himself, Mr. BENNET, Mr. COONS, Mr. HEINRICH, Mr. HICKENLOOPER, Mr. LUJÁN, Ms. SMITH, Mr. WHITEHOUSE, and Mr. WELCH) introduced the following bill; which was read twice and referred to the Committee on Health, Education, Labor, and Pensions

---

A BILL

To support carbon dioxide removal research and development, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the ''Carbon Dioxide Removal Research and Development Act of 2023''.

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:

SEC. 2. DEFINITIONS.

In this Act:

(1) CARBON DIOXIDE REMOVAL.—The term ''carbon dioxide removal'' means—

(A) the intentional capture of carbon dioxide directly from the ambient air or upper hydrosphere, combined with the storage of that carbon dioxide, which results in a net removal of carbon dioxide from the atmosphere, as measured on a lifecycle basis, including, at a minimum, through—

(i) direct air capture and storage;

(ii) enhanced carbon mineralization;

(iii) biomass-based carbon dioxide removal;

(iv) forest restoration;

(v) soil carbon management; and

(vi) ocean-based carbon removal.

(2) TERRESTRIAL AND BIOLOGICAL CARBON DIOXIDE REMOVAL.—The term ''terrestrial and biological carbon dioxide removal'' means carbon dioxide removal which uses living biomass or soils to capture and/or store carbon dioxide.

TITLE I—DEPARTMENT OF ENERGY

SEC. 101. FOSSIL ENERGY AND CARBON MANAGEMENT.

(a) OFFICE OF FOSSIL ENERGY AND CARBON MANAGEMENT.—

(1) IN GENERAL.—Title II of the Department of Energy Organization Act (42 U.S.C. 7131 et seq.) is amended by adding at the end the following:

"SEC. 218. OFFICE OF FOSSIL ENERGY AND CARBON MANAGEMENT.

''(a) ESTABLISHMENT.—There is established within the Department an Office of Fossil Energy and Carbon Management (referred to in this section as the 'Office').

''(b) ASSISTANT SECRETARY FOR FOSSIL ENERGY AND CARBON MANAGEMENT.—

''(1) IN GENERAL.—The Office shall be headed by the Assistant Secretary for Fossil Energy and Carbon Management (referred to in this section as the 'Assistant Secretary'), who shall be appointed by the President in accordance with section 203.

''(2) DUTIES OF OFFICE.—In carrying out research, development, and demonstration relating to carbon dioxide removal, the Assistant Secretary shall—

"(A) incorporate best practices from the existing carbon capture and storage research programs within the Department of Energy into the Office;

"(B) be responsible for crosscut coordination of planning and budget for all research, development, and demonstration programs of the Department of Energy relating to carbon dioxide removal (as defined in section 2 of the Carbon Dioxide Removal Research and Development Act of 2023);

"(C) serve as the primary point of contact for any relevant interagency planning and coordination efforts;

"(D) conduct analyses and technology assessments of carbon dioxide removal systems, development, and demonstration programs, including by engaging with the National Laboratories (as defined in section 2 of the Energy Policy Act of 2005 (42 U.S.C. 15801)) to assess lifecycle performance of carbon dioxide removal systems; and

"(E) provide project management services for all demonstration-scale projects emerging from the technological carbon dioxide removal

research, development, and demonstration portfolio.

''(c) MISSION.—The mission of the Office shall include the research, development, and demonstration of direct air capture and carbon mineralization technologies.

''(d) LEAD OFFICE.—The National Energy Technology Laboratory shall have the lead responsibility within the Department of Energy for planning and managing research, development, and demonstration activities relating to direct air capture and carbon storage, with the goal of establishing and driving down technology-specific cost targets.

''(e) PROJECT MANAGEMENT REQUIREMENTS.—All projects carried out by the Office shall be subject to rigorous project management requirements and procedures modeled on Department Order 413.3b (relating to program and project management for the acquisition of capital assets) (or a successor order).''.

(2) CLERICAL AMENDMENT.—The table of contents for the Department of Energy Organization Act (Public Law 95–91; 91 Stat. 565; 119 Stat. 764) is amended by adding at the end of the items relating to title II the following:

''Sec. 218. Office of Fossil Energy and Carbon Management.''.

(3) REFERENCES IN LAW.—Any reference in a law, regulation, document, paper, or other record to

the ''Office of Fossil Energy'' shall be deemed to be a reference to the ''Office of Fossil Energy and Carbon Management''.

(b) CARBON DIOXIDE REMOVAL RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—Section 969D of the Energy Policy Act of 2005 (42 U.S.C. 16298d) is amended—

(1) in subsection (c), by striking paragraph (5) and inserting the following:

''(5) ecologically sound, resilience-oriented, and carbon-sequestering forest management techniques, forest restoration, urban tree planting and management, and reforestation such that negative land-use change impacts, such as endangering food security and biodiversity loss, can be avoided; and'';

(2) by redesignating subsections (d), (e), (f), (g), (h), (i), (j), and (k) as subsections (e), (f), (g), (i), (j), (k), (l), and (m), respectively;

(3) by inserting after subsection (c) the following:

''(d) PROGRAM FOCUS AREAS.—

''(1) DIRECT AIR CAPTURE AND STORAGE TECHNOLOGIES.—In carrying out subsection (c)(1), the Secretary shall consider carrying out activities relating to—

"(A) contactor design;

"(B) low- and zero-carbon heat;

"(C) advanced or unconventional systems and components;

"(D) scale-up studies and pilot plants;

"(E) operational data collection;

"(F) engineering design support for large-scale projects;

"(G) external techno-economic analyses; and

"(H) monitoring, reporting, and verification capabilities.

"(2) BIOENERGY WITH CARBON CAPTURE AND STORAGE.—In carrying out subsection (c)(2), the Secretary shall consider carrying out activities relating to advanced biomass-to-power conversion.

"(3) ENHANCED GEOLOGICAL WEATHERING.—In carrying out subsection (c)(3), the Secretary shall consider carrying out activities relating to—

"(A) alkalinity resource assessments;

"(B) pilot studies of ex situ mineralization; and

"(C) pilot studies of in situ mineralization for carbon storage.

''(4) CARBON UTILIZATION.—In carrying out carbon utilization activities under the program, the Secretary shall consider carrying out activities relating to the integration of carbonation with carbon dioxide capture processes.

''(5) CROSSCUTTING ACTIVITIES.—In carrying out cross-cutting activities under the program, the Secretary shall consider carrying out activities relating to—

''(A) carbon dioxide removal data collection and publication;

''(B) technology cost and performance;

''(C) integrated carbon systems modeling; and

''(D) decision science.'';

(4) by inserting after subsection (g) (as so redesignated) the following:

''(h) COMPETITIVE DEMONSTRATION AWARDS.—

''(1) IN GENERAL.—Not later than 2 years after the date of enactment of this subsection the Secretary shall make competitive awards for a portfolio of carbon dioxide removal demonstration projects described in paragraph (2).

''(2) ELIGIBILITY.—Subject to subsection (e), to be eligible for an award under paragraph (1), a

carbon dioxide removal demonstration project shall—

"(A) use 1 or more technologies and strategies described in subsection (c), including activities described in subsection (i);

"(B) have a total cost of not less than $10,000,000;

"(C) be located in the United States or, in the case of ocean-based projects, within the territorial sea or exclusive economic zone of the United States;

"(D) have the potential for large-scale, cost-effective replication; and

"(E) meet such other provisions as may be established by the Secretary consistent with the purposes of this section.

"(3) ALLOCATION.—In making awards under paragraph (1), out of the funds provided under subsection (m)(1), the Secretary shall allocate—

"(A) $500,000,000 to projects with total costs of not less than $10,000,000 and not more than $100,000,000;

"(B) $750,000,000 to projects—

"(i) with a total cost of more than $100,000,000; and

"(ii) under which all captured carbon dioxide is disposed of in geologic storage in saline aquifers; and

"(C) $750,000,000 to projects with a total cost of more than $100,000,000, without regard to the type of storage.

"(4) COST-SHARE.—

"(A) IN GENERAL.—Except as provided in subparagraph (B), with respect to a project receiving an award under paragraph (1), the Secretary shall require that—

"(i) in the case of a project that disposes of carbon dioxide in geologic storage in an operating oil and gas field, not less than 50 percent of the total project cost shall be provided by a non-Federal source; and

"(ii) in the case of a project that is not described in clause (i), not less than 20 percent of the total project cost shall be provided by a non-Federal source.

"(B) EXCLUSION.—the Federal share of the cost of a project receiving an award under paragraph (1) with a total cost of not less than

$10,000,000 and not more than $100,000,000 may be up to 100 percent.''; and

(5) in subsection (m) (as so redesignated), by striking paragraphs (1) through (5) and inserting the following:

''(1) $2,089,000,000 for fiscal year 2024, of which $2,000,000,000 shall be used to carry out subsection (h), to remain available until expended;

''(2) $217,000,000 for fiscal year 2025;

''(3) $312,000,000 for fiscal year 2026;

''(4) $360,000,000 for fiscal year 2027;

''(5) $440,000,000 for fiscal year 2028;

''(6) $441,000,000 for fiscal year 2029;

''(7) $451,000,000 for fiscal year 2030;

''(8) $424,000,000 for fiscal year 2031;

''(9) $380,000,000 for fiscal year 2032; and

''(10) $337,000,000 for fiscal year 2033.''.

SEC. 102. ENERGY EFFICIENCY AND RENEWABLE ENERGY.

(a) ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGIES OFFICE.—

(1) IN GENERAL.—The Secretary of Energy shall establish direct air capture as a research priority of the Advanced Materials and Manufacturing Technologies Office, with a focus on improved tech-

niques for low-cost manufacturing of direct air capture components and materials.

(2) COORDINATION.—The Advanced Materials and Manufacturing Technologies Office shall carry out research relating to direct air capture under paragraph (1) in coordination with the Office of Fossil Energy and Carbon Management.

(3) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—The Secretary of Energy, acting through the Assistant Secretary for Energy Efficiency and Renewable Energy (referred to in this section as the ''Assistant Secretary''), shall carry out research, development, and demonstration activities in the areas described in this paragraph.

(A) SYSTEMS ENGINEERING AND PROCESS DESIGN.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to integrated catalyst reactor design optimized for carbon dioxide removal and utilization.

(B) ALKALINITY SOURCE PATHWAYS.—

(i) IN GENERAL.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to development of new, low-emissions

sources of alkalinity for carbon mineralization.

(ii) COLLABORATION.—The Assistant Secretary shall carry out the activities in clause (i) in collaboration with the Director of the United States Geological Survey.

(C) CONTACTOR DESIGN.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to design of air contactors for direct air capture with low pressure drop, high surface area, and high longevity.

(D) MANUFACTURING IMPROVEMENT.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to low-cost manufacturing of direct air capture components and materials.

(E) OTHER ACTIVITIES.—The Assistant Secretary shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary of Energy.

(b) BIOENERGY TECHNOLOGIES OFFICE.—

(1) IN GENERAL.—The Secretary of Energy shall establish terrestrial and biological carbon diox-

ide removal as a research objective in the biomass energy program of the Bioenergy Technologies Office.

(2) OBJECTIVE.—In carrying out research, development, and demonstration described in paragraph (5), the Secretary of Energy shall seek to advance carbon dioxide removal approaches that generate net-negative emissions based on full lifecycle analysis.

(3) CONSIDERATIONS.—In carrying out the full lifecycle analysis described in paragraph (2), the Bioenergy Technologies Office shall consider—

(A) the emissions impacts of biomass harvest and processing, including—

(i) unintended disturbances to ecosystem carbon stocks;

(ii) indirect land-use change; and

(iii) alternative fates of biomass used;

(B) the risk of impacts on biodiversity and food security; and

(C) the social impacts of any air pollutants.

(4) RISK CONSIDERATIONS.—In carrying out research, development, and demonstration described

in paragraph (5), the Bioenergy Technologies Office shall—

(A) conduct risk assessment of species cultivated or utilized for terrestrial and biological carbon dioxide removal; and

(B) take all feasible and prudent measures to minimize risk of economic, environmental, and social harm caused by invasive species.

(5) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(A) IN GENERAL.—The Secretary of Energy, acting through the Assistant Secretary, shall carry out research, development, and demonstration activities in the areas described in subparagraphs (B) through (I).

(B) ALGAL BIOMASS CAPTURE.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to microalgae growth, dewatering, and conversion, including pathways such as bioreactors and non-photosynthetic pathways.

(C) BIOMASS SUPPLY, LOGISTICS, AND PRE-TREATMENT.—

(i) IN GENERAL.—The Assistant Secretary, in collaboration with the Director

of the National Institute of Food and Agriculture, shall establish 1 or more test facilities to conduct innovative approaches for treating biomass for use in fuels and electricity generation, including modeling and analysis of optimizing biomass gathering, upgrading, and supply.

(ii) TEST FACILITY CONSIDERATIONS.—In selecting facilities to be established as test facilities under clause (i), the Assistant Secretary shall—

(I) consider whether the facility has the capability for small-scale and mobile applications; and

(II) prioritize facilities that use waste feedstocks from managed ecosystems, urban areas, and areas damaged by severe weather events.

(D) BIOMASS CONVERSION TO FUELS WITH BIOCHAR.—

(i) IN GENERAL.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to—

(I) research on conversion pathways, including fast pyrolysis;

(II) development of—

(aa) mobile processing units; and

(bb) pollutant emissions control technology; and

(III) assessments of overall carbon dioxide removal potential.

(ii) COLLABORATION.—The Assistant Secretary shall carry out the activities under clause (i) in collaboration with the Director of the National Institute of Food and Agriculture.

(E) BIOMASS TO FUEL WITH CARBON CAPTURE AND STORAGE.—

(i) IN GENERAL.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to biomass to advanced cellulosic ethanol with carbon capture and storage, taking into consideration direct and indirect land-use impacts from biomass feedstocks.

(ii) COLLABORATION.—The Assistant Secretary shall carry out the activities

under clause (i) in collaboration with the Assistant Secretary for Office of Fossil Energy and Carbon Management.

(F) AQUATIC BIOMASS CULTIVATION.—

(i) IN GENERAL.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to management best practices and phenotype selection for aquatic macroalgae biomass production optimized for carbon dioxide removal, including limited-scale experiments at sea, designed and monitored to avoid impacts beyond the zone of the experiment.

(ii) COLLABORATION.—The Assistant Secretary shall carry out the activities under clause (i) in collaboration with the Administrator of the National Oceanic and Atmospheric Administration.

(G) AQUATIC BIOMASS ENERGY CONVERSION.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to technology development and pilots for aquatic biomass conversion and car-

bon capture, including possible large-scale ocean-based experiments.

(H) NEW MATERIALS DEVELOPMENT AND APPLICATIONS.—

(i) IN GENERAL.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to development of new carbon dioxide utilization products.

(ii) COLLABORATION.—The Assistant Secretary shall carry out the activities under clause (i) in collaboration with—

(I) the Assistant Secretary for Fossil Energy and Carbon Management; and

(II) the Administrator of the Agricultural Research Service.

(I) OTHER ACTIVITIES.—The Assistant Secretary shall carry out research, development, and demonstration activities relating to other terrestrial and biological carbon dioxide removal research, development, and demonstration activities not described in subparagraphs (B) through (H), as determined by the Secretary.

(c) BUILDING TECHNOLOGIES OFFICE.—

(1) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—The Secretary of Energy, acting through the Building Technologies Office, shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) CONSTRUCTION MATERIALS.—

(A) IN GENERAL.—The Building Technologies Office shall carry out research, development, and demonstration activities relating to development, testing, and certification of carbonate materials for construction materials.

(B) COLLABORATION.—The Building Technologies Office shall carry out activities under clause (i) in collaboration with the National Institute of Standards and Technology.

(3) OTHER ACTIVITIES.—The Building Technologies Office shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary of Energy.

(d) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary of Energy to carry out this section—

(1) $26,000,000 for fiscal year 2024;

(2) $54,000,000 for fiscal year 2025;

(3) $83,000,000 for fiscal year 2026;

(4) $93,000,000 for fiscal year 2027;

(5) $93,000,000 for fiscal year 2028;

(6) $88,000,000 for fiscal year 2029;

(7) $83,000,000 for fiscal year 2030;

(8) $73,000,000 for fiscal year 2031;

(9) $53,000,000 for fiscal year 2032; and

(10) $42,000,000 for fiscal year 2033.

SEC. 103. OFFICE OF SCIENCE.

(a) RESEARCH.—

(1) IN GENERAL.—The Secretary of Energy, acting through the Director of the Office of Science (referred to in this section as the ''Director''), shall carry out use-inspired fundamental research activities in each of the areas described in this subsection.

(2) DEPARTMENT OF ENERGY FRONTIER RESEARCH CENTERS.—The Director shall carry out research activities relating to the establishment of new energy frontier research centers focused on materials research and early-stage application of sorbents, solvents, membranes, and related direct air capture components.

(3) GRANTS AND COOPERATIVE AGREEMENTS.—The Director shall make grants and enter into cooperative agreements to carry out materials

research relating to sorbents, solvents, membranes, and related direct air capture components.

(4) SOIL CARBON.—

(A) IN GENERAL.—The Director shall carry out research activities relating to plant-root-fungi interactions, deep inversion of soils, and other topics.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with—

(i) the Director of the National Science Foundation; and

(ii) the Director of the Agricultural Research Service.

(5) ALGAL BIOMASS CAPTURE.—The Director shall carry out research activities relating to—

(A) microalgae growth;

(B) dewatering; and

(C) conversion, including bioreactors and nonphotosynthetic pathways.

(6) CARBON MINERALIZATION.—

(A) IN GENERAL.—The Director shall carry out research activities relating to—

(i) mineralization kinetics;

(ii) geomechanics;

(iii) rock physics;

(iv) utilization-oriented carbonation; and

(v) other topics.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(7) OCEAN ALKALINITY.—

(A) IN GENERAL.—The Director shall carry out research activities relating to techniques for and ecological impacts of artificial modification of ocean alkalinity.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(8) CARBON CYCLE.—

(A) IN GENERAL.—The Director shall carry research activities and modeling relating to—

(i) the effectiveness and ecological impacts of ocean iron fertilization; and

(ii) nitrogen and phosphorous fertilization.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with—

(i) the Director of the National Science Foundation; and

(ii) the Administrator of the National Oceanic and Atmospheric Administration.

(9) CARBON DIOXIDE IMPACTS AND FATE IN OCEANS.—

(A) IN GENERAL.—The Director shall carry out monitoring, research, and modeling on ecological impacts of ocean carbon dioxide removal techniques.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with the Administrator of the National Oceanic and Atmospheric Administration.

(10) CARBONATION.—

(A) IN GENERAL.—The Director shall carry out research activities relating to—

(i) methods to control carbonation reactions;

(ii) methods to accelerate carbonation; and

(iii) research to understand structure-property relationships.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(11) CATALYSTS.—

(A) IN GENERAL.—The Director shall carry out research activities relating to—

(i) impurity-tolerant catalyst development;

(ii) coupled reduction and oxidation reactions; and

(iii) reduced additives.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(12) NEW MATERIALS DEVELOPMENT AND APPLICATIONS.—

(A) IN GENERAL.—The Director shall carry out research activities relating to development of new materials for capturing and utilizing carbon dioxide, including materials with carbon-carbon bonds.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(13) GENETIC MODELING AND TOOLS.—

(A) IN GENERAL.—The Director shall carry out research, development, and demonstration of technologies to improve carbon dioxide uptake, conversion, and product accumulation through genetic manipulation of biological organisms for carbon dioxide removal and utilization.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(14) BIOPROSPECTING.—

(A) IN GENERAL.—The Director shall carry out research activities relating to development of tools and high-throughput screening for organisms with unique attributes relating to carbon dioxide conversion.

(B) COLLABORATION.—The Director shall carry out the activities under subparagraph (A)

in collaboration with the Administrator of the Agricultural Research Service.

(15) OTHER RESEARCH.—The Director shall carry out other research on carbon dioxide removal, as determined by the Secretary.

(b) COORDINATION.—The Director shall carry out this section in coordination with the Assistant Secretary for Fossil Energy and Carbon Management.

(c) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary of Energy to carry out this section—

(1) $30,000,000 for fiscal year 2024;

(2) $65,000,000 for fiscal year 2025;

(3) $79,000,000 for fiscal year 2026;

(4) $83,000,000 for fiscal year 2027;

(5) $88,000,000 for fiscal year 2028;

(6) $84,000,000 for fiscal year 2029;

(7) $81,000,000 for fiscal year 2030;

(8) $70,000,000 for fiscal year 2031;

(9) $70,000,000 for fiscal year 2032; and

(10) $67,000,000 for fiscal year 2033.

SEC. 104. DEPARTMENT-WIDE CONSIDERATIONS.

(a) LIFECYCLE ANALYSES.—In carrying out research, development, and demonstration under this title, the Secretary of Energy, in collaboration with the heads

of other appropriate Federal agencies, shall conduct full-system lifecycle analyses of emissions and other environmental impacts from carbon dioxide removal technologies and methods.

(b) ENVIRONMENTAL JUSTICE ANALYSES.—In carrying out research, development, and demonstration under this title, the Secretary of Energy shall conduct environmental justice analyses of carbon dioxide removal technologies, methods, and siting, including impacts on local and regional conventional air pollution.

TITLE II—DEPARTMENT OF AGRICULTURE

SEC. 201. DEFINITIONS.

In this title:

(1) DEPARTMENT.—The term ''Department'' means the Department of Agriculture.

(2) LAND-GRANT COLLEGES AND UNIVERSITIES.—

(A) IN GENERAL.—The term ''land-grant colleges and universities'' has the meaning given the term in section 1404 of the National Agricultural Research, Extension, and Teaching Policy Act of 1977 (7 U.S.C. 3103).

(B) INCLUSION.—The term ''land-grant colleges and universities'' includes a 1994 Insti-

tution (as defined in section 532 of the Equity in Educational Land-Grant Status Act of 1994 (7 U.S.C. 301 note; Public Law 103–382)).

(3) SECRETARY.—The term ''Secretary'' means the Secretary of Agriculture.

SEC. 202. OBJECTIVES AND ORGANIZATION.

(a) DEPARTMENTAL MISSION.—The Secretary shall incorporate terrestrial and biological carbon dioxide removal mission responsibilities into the Strategic Plan of the Department to complement the food and fiber mission responsibilities of the Department.

(b) UNDER SECRETARY FOR RESEARCH, EDUCATION, AND ECONOMICS.—

(1) IN GENERAL.—The Under Secretary for Research, Education, and Economics (referred to in this section as the ''Under Secretary'') shall—

(A) coordinate all carbon dioxide removal research, development, and demonstration activities within the Department; and

(B) in carrying out subparagraph (A), collaborate with other senior Department officials with related responsibilities, including the Chief Economist.

(2) REVIEW AND ADVISE.—The Under Secretary shall—

(A) review and advise the Secretary on all budget proposals relating to carbon dioxide removal research, development, and demonstration under Department programs; and

(B) provide oversight and evaluation of carbon dioxide removal research, development, and demonstration initiatives and projects of the Department.

(3) RESEARCH STRATEGIES.—In carrying out this subsection, the Under Secretary shall pursue research strategies that build on well-established agriculture research infrastructure to pursue carbon dioxide removal research, development, and demonstration objectives through new research models.

(4) RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAMS.—The Under Secretary shall incorporate terrestrial and biological carbon dioxide removal research, development, and demonstration programs and projects—

(A) across the Department, including at—

(i) the Agricultural Research Service;

(ii) the Forest Service;

(iii) the Natural Resources Conservation Service;

(iv) the National Institute of Food and Agriculture; and

(v) other Department agencies and offices; and

(B) in research portfolios of land-grant colleges and universities.

(c) DEPARTMENT-WIDE CONSIDERATIONS.—

(1) OBJECTIVE.—In carrying out research, development, and demonstration under this title, the Secretary shall seek to advance carbon dioxide removal approaches that generate net-negative emissions based on full lifecycle analysis.

(2) CONSIDERATIONS.—In carrying out this title, the Secretary shall consider, in addition to emissions described in paragraph (1), the risk of impacts on biodiversity and food security, social impacts, and such other impacts as the Secretary determines to be appropriate.

(3) RISK CONSIDERATIONS.—In carrying out this title, the Secretary shall—

(A) conduct risk assessment of species cultivated or utilized for terrestrial and biological carbon dioxide removal; and

(B) take all feasible and prudent measures to minimize risk of economic, environmental, and social harm caused by invasive species.

(4) MEMORANDUM OF UNDERSTANDING.—The Secretary shall enter into a memorandum of understanding with the Secretary of Energy to incorporate carbon dioxide removal scientific objectives into—

(A) current joint research on genomics and synthetic biology; and

(B) new and expanded joint research initiatives between the National Laboratories (as defined in section 2 of the Energy Policy Act of 2005 (42 U.S.C. 15801)) and land-grant colleges and universities.

SEC. 203. AGRICULTURE ADVANCED RESEARCH AND DEVELOPMENT AUTHORITY.

Section 1473H of the National Agricultural Research, Extension, and Teaching Policy Act of 1977 (7 U.S.C. 3319k) is amended—

(1) in subsection (b)(2)—

(A) in subparagraph (C), by striking ''and'' at the end;

(B) in subparagraph (D), by striking the period at the end and inserting ''; and''; and

(C) by adding at the end the following:

''(E) to advance technologies and methods relating to terrestrial and biological carbon dioxide removal (as defined in section 2 of the Carbon Dioxide Removal Research and Development Act of 2023).''; and

(2) in subsection (d), by adding at the end the following:

''(4) AUTHORIZATION OF APPROPRIATIONS FOR CARBON DIOXIDE REMOVAL ACTIVITIES.—In addition to amounts otherwise made available under this subsection, there are authorized to be appropriated to carry out subsection (b)(2)(E), $10,000,000 for each of fiscal years 2024 through 2033, to remain available until expended.''.

SEC. 204. NATIONAL INSTITUTE OF FOOD AND AGRICULTURE.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary, acting through the National Institute of Food and Agriculture, shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) BIOMASS SUPPLY, LOGISTICS, AND PRETREATMENT.—

(A) IN GENERAL.—The Secretary shall establish 1 or more test facilities for innovative approaches for treating biomass for use in fuels and electricity generation, including modeling and analysis of optimizing biomass gathering, upgrading, and supply.

(B) CONSIDERATION; PRIORITY.—In carrying out subparagraph (A), the Secretary shall—

(i) consider facilities with the capability for small-scale and mobile applications; and

(ii) prioritize waste feedstocks from managed ecosystems, urban areas, and areas damaged by severe weather events.

(3) BIOMASS CONVERSION TO FUELS WITH BIOCHAR.—The Secretary shall—

(A) research pathways for the conversion of biomass to fuels with biochar, including fast pyrolysis, development of mobile processing units, and pollution emissions control technology; and

(B) conduct relevant assessments of overall carbon dioxide removal potential.

(4) OTHER ACTIVITIES.—The Secretary shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary.

(b) COLLABORATION.—In carrying out the activities under subsection (a), the Secretary shall collaborate with the Assistant Secretary for Energy Efficiency and Renewable Energy.

(c) CONSIDERATION.—In carrying out research, development, and demonstration on biomass as a feedstock, the Secretary shall consider—

(1) the emissions impacts of biomass harvest and processing;

(2) unintended disturbances to ecosystem carbon stocks;

(3) indirect land-use change;

(4) alternative fates of biomass used; and

(5) the social impacts of any air pollutants.

(d) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary to carry out this section—

(1) $6,000,000 for fiscal year 2024;

(2) $15,000,000 for fiscal year 2025;

(3) $25,000,000 for fiscal year 2026;

(4) $30,000,000 for each of fiscal years 2027 through 2030;

(5) $25,000,000 for fiscal year 2031;

(6) $18,000,000 for fiscal year 2032; and

(7) $15,000,000 for fiscal year 2033.

SEC. 205. AGRICULTURAL RESEARCH SERVICE.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary, acting through the Agricultural Research Service, shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) SOIL CARBON.—

(A) IN GENERAL.—The Secretary shall carry out fundamental research on plant-root-fungi interactions, deep inversion of soils, and other topics with the potential to advance carbon dioxide removal.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with—

(i) the Director of the Office of Science of the Department of Energy; and

(ii) the Director of the National Science Foundation.

(3) HIGH-CARBON-INPUT CROP PHENOTYPES.—

(A) IN GENERAL.—The Secretary shall carry out development of advanced cultivars and forestry crops with enhanced carbon uptake and retention.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Chief of the Forest Service.

(4) CULTIVATION SYSTEM OPTIMIZATION.—

(A) IN GENERAL.—The Secretary shall carry out research on regionally specific best practices for soil health and carbon retention at not fewer than 10 sites, including at least 1 site in a tropical region.

(B) CONSIDERATION.—The Secretary shall consider co-locating sites described in subparagraph (A) with sites used by the National Resource Inventory of the Natural Resources Conservation Service, the Long Term Ecological Research Network, the National Ecological Observatory Network, and the Forest Inventory and Analysis Program.

(5) AGROFORESTRY.—The Secretary shall carry out research on integrating regionally appropriate trees and shrubs into crop and animal farming systems as a carbon dioxide removal practice at no fewer than 5 geographically diverse test sites.

(6) PERENNIAL PLANTS AND MARGINAL LANDS.—The Secretary shall carry out research into the use of perennial plants for carbon dioxide removal, including research on—

(A) genetic traits;

(B) improved soil carbon sequestration modeling;

(C) perennialization of useful annual crops; and

(D) greater use on marginal land.

(7) SOIL AMENDMENTS IMPACT STUDIES.—The Secretary shall carry out research and field studies on the longevity and impact of soil amendments, such as biochar and reactive minerals, on productivity, soil carbon retention, nutrient and water use, albedo, and other factors.

(8) MEASUREMENT, MODELING, AND PREDICTIVE TOOL DEVELOPMENT.—

(A) IN GENERAL.—The Secretary shall carry out research to improve existing carbon

sequestration measurement and modeling tools and the development of simulation-based tools to predict and quantify soil carbon sequestration.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(9) CLIMATE HUBS.—

(A) IN GENERAL.—The Secretary shall carry out activities relating to increasing the capacity of Department climate hubs and other research units to deliver climate- and carbon dioxide removal-related science and tools to farmers, ranchers, and forest planners and managers.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Chief of the Forest Service.

(10) BIOPROSPECTING.—

(A) IN GENERAL.—The Secretary shall carry out activities relating to the development of tools and high-throughput screening for or-

ganisms with unique attributes relating to carbon dioxide conversion.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Director of the Office of Science of the Department of Energy.

(11) NEW MATERIALS DEVELOPMENT AND APPLICATIONS.—

(A) IN GENERAL.—The Secretary shall carry out activities relating to development of new carbon dioxide utilization products.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Assistant Secretary for Office of Energy Efficiency and Renewable Energy of the Department of Energy.

(12) OTHER ACTIVITIES.—The Secretary shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary to carry out this section—

(1) $45,000,000 for fiscal year 2024;

(2) $52,000,000 for fiscal year 2025;

(3) $61,000,000 for fiscal year 2026;

(4) $72,000,000 for each of fiscal years 2027 and 2028; and

(5) $68,000,000 for each of fiscal years 2029 through 2033.

SEC. 206. NATURAL RESOURCES CONSERVATION SERVICE.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary, acting through the Natural Resources Conservation Service, shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) ENHANCED SOIL MONITORING.—

(A) IN GENERAL.—The Secretary shall carry out revisions to the National Resources Inventory system of the National Resources Conservation Service—

(i) to include measuring greenhouse gasses, including carbon stocks and fluxes;

(ii) to include additional sites; and

(iii) to expand remote sensing to increase frequency and geospatial resolution.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Administrator of the National Aeronautics and Space Administration.

(3) CONSERVATION PRACTICES DATA COLLECTION.—The Secretary shall carry out revisions to the Conservation Effects Assessment Project of the Natural Resources Conservation Service to collect more frequent and robust data on how conservation practices impact greenhouse gas fluxes.

(4) EXTENSION OF AGRICULTURAL CARBON SEQUESTRATION PRACTICES.—The Secretary shall carry out—

(A) projects to identify barriers to adoption of agricultural carbon sequestration technologies; and

(B) extension of tools and practices, and research to promote uptake using existing conservation programs of the Department.

(5) SOCIAL SCIENCE RESEARCH.—

(A) IN GENERAL.—The Secretary shall carry out social science research on uptake of agricultural carbon sequestration technologies and practices to inform outreach.

(B) CONSULTATION.—The Secretary shall carry out the activities under subparagraph (A) in consultation with the Administrator of the Economic Research Service.

(6) OTHER ACTIVITIES.—The Secretary shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary to carry out this section—

(1) $6,000,000 for each of fiscal years 2024 through 2026;

(2) $10,000,000 for each of fiscal years 2027 and 2028; and

(3) $6,000,000 for each of fiscal years 2029 through 2033.

SEC. 207. FOREST SERVICE.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary, acting through the Chief of the Forest Service, shall carry out research, development, and demonstration activities in at each of the areas described in this subsection.

(2) ENHANCED FOREST STOCK MONITORING.—

(A) IN GENERAL.—The Secretary shall carry out activities relating to improving—

(i) capacity of the Forest Inventory and Analysis program to monitor forest carbon, including through remote sensing to increase frequency and geospatial resolution; and

(ii) forest carbon measurement and monitoring technologies, including satellite and remote sensing technologies.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Administrator of the National Aeronautics and Space Administration.

(3) INTEGRATED ASSESSMENT MODEL AND GRASSLANDS AND FOREST IMPACTS MODELING.—

(A) IN GENERAL.—The Secretary shall carry out activities relating to technical, economic, and social modeling of impacts on land use from avoided conversion of grasslands and forests, reforestation, conservation, afforestation, and forest management changes.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Director of the National Science Foundation.

(4) FOREST CARBON MANAGEMENT DEMONSTRATION.—

(A) IN GENERAL.—The Secretary shall carry out activities, at not fewer than 5 geographically diverse sites, relating to conducting large-scale field experiments of best practices for forest management and restoration that optimize carbon dioxide removal while maintaining and enhancing ecosystems.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Assistant Administrator for Research and Development of the Environmental Protection Agency.

(5) CLIMATE RESILIENCE.—The Secretary shall carry out research and field experiments on enhancements to forest management practices for carbon dioxide removal to reflect emerging needs due to the impact of climate change on forests over time.

(6) PRESERVATION OF HARVESTED WOOD.—

(A) IN GENERAL.—The Secretary shall carry out activities relating to the design and demonstration of landfills for woody biomass disposal and carbon storage.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Assistant Administrator for Research and Development of the Environmental Protection Agency.

(7) SOCIAL SCIENCE RESEARCH AND EXTENSION.—The Secretary shall carry out social science research and extension programs to promote uptake of forest management carbon sequestration technologies and practices.

(8) CLIMATE HUBS.—

(A) IN GENERAL.—The Secretary shall carry out activities to increase the capacity of Department climate hubs and other research units to deliver climate and carbon dioxide removal-related science and tools to forest planners and managers.

(B) COLLABORATION.—The Secretary shall carry out the activities under subparagraph (A) in collaboration with the Administrator of the Agricultural Research Service.

(9) OTHER ACTIVITIES.—The Secretary shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary to carry out this section—

(1) $24,000,000 for each of fiscal years 2024 through 2026;

(2) $16,000,000 for each of fiscal years 2027 and 2028; and

(3) $10,000,000 for each of fiscal years 2029 through 2033.

TITLE III—DEPARTMENT OF COMMERCE

SEC. 301. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION.

(a) DEFINITION OF UNDER SECRETARY.—In this section, the term ''Under Secretary'' means the Under Secretary of Commerce for Oceans and Atmosphere.

(b) STRATEGIC MISSION OBJECTIVE.—The Secretary of Commerce shall incorporate carbon dioxide removal scientific objectives into the mission responsibilities of the National Oceanic and Atmospheric Administration for oceans and coastal area programs.

(c) RESEARCH OBJECTIVES AND CONSIDERATIONS.—

(1) OBJECTIVES.—In carrying out research, development, and demonstration under this section, the Under Secretary shall seek to develop a better understanding of the efficacy and impacts of carbon dioxide removal approaches in coastal areas and the ocean to help determine which could be feasible for larger scale deployment.

(2) CONSIDERATIONS.—In carrying out research, development, and demonstration under this section, the Under Secretary shall conform to national and international governance frameworks and employ stringent monitoring to understand and minimize negative ecosystem and social impacts and maximize co-benefits for communities and marine ecosystems.

(d) LEAD OFFICE.—

(1) CLIMATE PROGRAM OFFICE.—The Climate Program Office of the National Oceanic and Atmospheric Administration (referred to in this subsection as the ''Office'') shall serve as the focal point for coordination and information dissemination on carbon dioxide removal activities across the National Oce-

anic and Atmospheric Administration, with an emphasis on technological approaches.

(2) RESPONSIBILITIES.—The Office shall—

(A) coordinate all National Oceanic and Atmospheric Administration carbon dioxide removal research, development, and demonstration on technologically enhanced coastal and ocean carbon capture, conversion, and storage;

(B) support the development and application of technologically enhanced methods of coastal and ocean carbon dioxide removal consistent with the research objectives and considerations described in subsection (c); and

(C) ensure effective utilization of the ocean research assets of the Administration, the National Science Foundation, and the Coast Guard in implementing carbon dioxide removal research projects.

(3) INTEGRATION.—The Director of the Office shall—

(A) coordinate existing ocean acidification monitoring and data collection programs in existence as of the date of enactment of this Act with the carbon dioxide removal research port-

folio of the National Oceanic and Atmospheric Administration; and

(B) modify existing ocean acidification program plans to incorporate carbon dioxide removal research objectives.

(e) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Under Secretary shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) COASTAL MARINE CARBON FUNDAMENTAL RESEARCH.—

(A) IN GENERAL.—The Under Secretary shall carry out fundamental research of coastal ecosystem carbon dioxide sequestration.

(B) COLLABORATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in collaboration with the Director of the National Science Foundation.

(3) COASTAL RESOURCE ASSESSMENT.—

(A) IN GENERAL.—The Under Secretary shall carry out mapping and evaluation of coastal marine ecosystems for carbon dioxide removal potential.

(B) COLLABORATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in collaboration with the Administrator of the National Aeronautics and Space Administration.

(4) COASTAL MARINE CARBON REGIONAL FIELD TRIALS.—

(A) IN GENERAL.—The Under Secretary shall carry out monitored field trials of coastal wetlands restoration optimized for carbon dioxide removal.

(B) COORDINATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in coordination with the grant program under section 906 of the National Oceans and Coastal Security Act (16 U.S.C. 7505) and the Ecosystem Management and Restoration Research Program of the Corps of Engineers.

(5) NATIONAL COASTAL WETLAND DATA CENTER.—The Under Secretary shall integrate data on coastal ecosystem carbon dioxide removal research into the Digital Coast program established under section 4(a) of the Digital Coast Act (16 U.S.C. 1467(a)).

(6) OCEAN MODELING.—The Under Secretary shall conduct research and modeling on the effect of ocean circulation on carbon dioxide uptake from the atmosphere in response to intentional carbon dioxide removal from the ocean.

(7) AQUATIC BIOMASS CULTIVATION.—

(A) IN GENERAL.—The Under Secretary shall research management best practices and phenotype selection for and use of aquatic macroalgae biomass production optimized for carbon dioxide removal, including limited-scale experiments at sea, designed and monitored to avoid impacts beyond the zone of the experiment.

(B) COLLABORATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in collaboration with the Assistant Secretary for Energy Efficiency and Renewable Energy of the Department of Energy.

(C) RISK CONSIDERATIONS.—The Under Secretary shall take all feasible and prudent measures to minimize risk of economic, environmental, and social harm caused by invasive species.

(8) APPLIED ALKALINITY MODIFICATION TECHNIQUES.—

(A) IN GENERAL.—The Under Secretary shall conduct limited-scale experiments on alkalinity enhancement techniques at sea, designed and monitored to avoid impacts beyond the zone of the experiment.

(B) COLLABORATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in collaboration with the Director of the National Science Foundation.

(9) SEAWATER CARBON EXTRACTION.—The Under Secretary shall conduct research and modeling on electrochemical seawater extraction, including process design and locations for minimizing resource requirements, downstream chemical and biological impacts, and storage or utilization methods.

(10) OCEAN FERTILIZATION FUNDAMENTAL RESEARCH.—

(A) IN GENERAL.—The Under Secretary shall conduct fundamental research and modeling on the impacts and effectiveness of ocean iron fertilization and nitrogen and phosphorous fertilization research.

(B) COLLABORATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in collaboration with the Director of the National Science Foundation and the Director of the Office of Science of the Department of Energy.

(11) ARTIFICIAL OCEAN MACRONUTRIENT FERTILIZATION.—

(A) IN GENERAL.—The Under Secretary shall conduct limited-scale experiments on ocean macronutrient fertilization, designed and monitored to avoid impacts beyond the zone of the experiment and within internationally recognized frameworks.

(B) COLLABORATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in collaboration with the Director of the National Science Foundation.

(12) UPWELLING AND DOWNWELLING.—The Under Secretary shall conduct research on the impact and effectiveness of upwelling and downwelling as a carbon dioxide removal approach.

(13) CARBON DIOXIDE IMPACTS AND FATE IN OCEANS.—

(A) IN GENERAL.—The Under Secretary shall conduct monitoring, research, modeling, and small-scale field trials on ecological and social impacts of coastal and deep ocean carbon dioxide removal techniques.

(B) COLLABORATION.—The Under Secretary shall carry out the activities described in subparagraph (A) in collaboration with the Director of the Office of Science of the Department of Energy.

(14) ENHANCED MONITORING.—The Under Secretary shall conduct enhanced ocean, coastal, and atmospheric monitoring, quantification, and verification of carbon dioxide removal.

(15) OTHER ACTIVITIES.—The Under Secretary shall conduct other carbon dioxide removal research, development, and demonstration activities, as determined by the Under Secretary.

(f) INPUT.—In carrying out the activities under subsection (e), the Under Secretary shall receive input from the Director of the Office.

(g) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Under Secretary to carry out subsection (d)—

(1) $25,000,000 for fiscal year 2024;

(2) $50,000,000 for fiscal year 2025;

(3) $100,000,000 for fiscal year 2026;

(4) $124,000,000 for fiscal year 2027;

(5) $148,000,000 for fiscal year 2028;

(6) $150,000,000 for fiscal year 2029;

(7) $138,000,000 for fiscal year 2030;

(8) $126,000,000 for fiscal year 2031;

(9) $117,000,000 for fiscal year 2032; and

(10) $105,000,000 for fiscal year 2033.

(h) INTERNATIONAL COORDINATION.—In carrying out this section, the Under Secretary, acting through the Director of the Office, shall—

(1) coordinate with the Secretary of State and appropriate international entities;

(2) ensure compliance with all current international agreements, including voluntary compliance agreements where the United States is not an official signatory; and

(3) to the extent practicable, seek joint sponsorship for experiments.

SEC. 302. NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary of Commerce, acting through the Director of the National Institute of Standards and Technology (referred to in this section as the ''Director''), shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) MATERIALS TESTING AND STANDARDS.—The Director shall develop standard reference materials and standard testing procedures for technologies and processes related to carbon dioxide removal.

(3) CONSTRUCTION MATERIALS.—

(A) IN GENERAL.—The Director shall develop, test, and establish standards for carbonate or carbon-sequestering materials for construction markets.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Assistant Secretary for Energy Efficiency and Renewable Energy of the Department of Energy.

(4) OTHER ACTIVITIES.—The Director shall conduct other carbon dioxide removal research, development, and demonstration activities, as deter-

mined by the Director of the National Institute of Standards and Technology.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Director of the National Institute of Standards and Technology to carry out this section—

(1) $4,000,000 for each of fiscal years 2024 through 2026;

(2) $7,000,000 for each of fiscal years 2027 through 2029;

(3) $2,000,000 for each of fiscal years 2030 through 2032; and

(4) $1,000,000 for fiscal year 2033.

TITLE IV—DEPARTMENT OF DEFENSE

SEC. 401. CORPS OF ENGINEERS.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary of Defense, acting through the Chief of Engineers, shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) COASTAL MARINE CARBON REGIONAL FIELD TRIALS.—

(A) IN GENERAL.—The Secretary of Defense, acting through the Chief of Engineers, shall carry out monitored field trials of coastal wetlands restoration optimized for carbon dioxide removal.

(B) COORDINATION.—The Secretary of Defense, acting through the Chief of Engineers, shall carry out the activities described in subparagraph (A) in coordination with the grant program under section 906 of the National Oceans and Coastal Security Act (16 U.S.C. 7505) and the Coastal Resilience Grants Program of the National Oceanic and Atmospheric Administration.

(3) OTHER ACTIVITIES.—The Secretary of Defense, acting through the Chief of Engineers, shall conduct other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary of Defense.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary of Defense to carry out this section—

(1) $24,000,000 for fiscal year 2024;

(2) $45,000,000 for each of fiscal years 2025 through 2027;

(3) $53,000,000 for each of fiscal years 2028 through 2030; and

(4) $25,000,000 for each of fiscal years 2031 through 2033.

TITLE V—DEPARTMENT OF THE INTERIOR

SEC. 501. UNITED STATES GEOLOGICAL SURVEY.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary of the Interior, acting through the Director of the United States Geological Survey (referred to in this section as the ''Director''), shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) RESOURCE ASSESSMENTS.—

(A) IN GENERAL.—The Director shall—

(i) carry out mapping and technical and economic assessments of geological resources, mine tailings, and other alkaline industrial wastes for mineralization; and

(ii) establish of a public database of results of the mapping and assessments carried out under clause (i).

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy.

(3) TAILINGS AND WASTE MINERALIZATION.—

(A) IN GENERAL.—The Director shall carry out field experiments on carbon-sequestering waste materials, including mine tailings and industrial wastes.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Assistant Secretary for of Fossil Energy and Carbon Management of the Department of Energy;

(ii) the Assistant Administrator for of Research and Development of the Environmental Protection Agency; and

(iii) the director of the Bureau of Land Management.

(4) ENVIRONMENTAL IMPACTS OF MINERALIZATION MATERIALS.—

(A) IN GENERAL.—The Director shall carry out research on the environmental im-

pacts of broadcasting materials, including disturbing piles of mine tailings.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy; and

(ii) the Assistant Administrator for Research and Development of the Environmental Protection Agency.

(5) ENVIRONMENTAL AND SOCIAL IMPACTS OF EXPANDED MINING FOR MINERALIZATION.—

(A) IN GENERAL.—The Director shall carry out research on the environmental and social impacts of expanded mining activities for the purpose of mineralization, including the net carbon impact of those activities.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Director of the National Science Foundation;

(ii) the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy; and

(iii) the Assistant Administrator for Research and Development of the Environmental Protection Agency.

(6) NEW MINERALIZATION PATHWAYS.—

(A) IN GENERAL.—The Director shall carry out development of new, low-emissions sources of alkalinity for carbon mineralization and new mineralization processes, such as looping and direct air capture hybrids.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Assistant Secretary for Energy Efficiency and Renewable Energy of the Department of Energy.

(7) REGIONAL PARTNERSHIPS.—

(A) IN GENERAL.—The Director shall establish not more than 6 regional partnerships, the membership of which may be made up of 1 or more—

(i) institutions of higher education;

(ii) State entities;

(iii) Federal entities;

(iv) Indian Tribes (as defined in section 4 of the Indian Self-Determination and Education Assistance Act (25 U.S.C. 5304));

(v) Native Hawaiian organizations (as defined in section 6207 of the Elementary and Secondary Education Act of 1965 (20 U.S.C. 7517));

(vi) nongovernmental organizations; and

(vii) other relevant entities.

(B) PURPOSE.—The purpose of a regional partnership established under subparagraph (A) shall be—

(i) to characterize regional resources for mineralization; and

(ii) to carry out field experiments and small-scale demonstration projects for mineralization.

(C) COLLABORATION.—The Director shall carry out the activities described in this paragraph in collaboration with the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy.

(8) OTHER ACTIVITIES.—The Director shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary of the Interior.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary of Interior to carry out this section—

(1) $13,000,000 for fiscal year 2024;

(2) $19,000,000 for fiscal year 2025;

(3) $22,000,000 for each of fiscal years 2026 through 2030;

(4) $21,000,000 for each of fiscal years 2031 and 2032; and

(5) $18,000,000 for fiscal year 2033.

SEC. 502. LAND AND MINERALS MANAGEMENT.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Secretary of the Interior, acting through the Assistant Secretary of Land and Minerals Management (referred to in this section as the ''Assistant Secretary''), shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) CARBON DIOXIDE REMOVAL ON FEDERAL LANDS.—

(A) IN GENERAL.—The Assistant Secretary shall carry out an assessment of the ability to use Federal land and abandoned mine land, subject to the Office of Surface Mining, and associated subsurface regions, for carbon dioxide removal benefits and practices, including—

(i) ecologically appropriate revegetation;

(ii) reforestation;

(iii) restoration to natural landscapes, including grasslands; and

(iv) underground geologic storage of carbon dioxide.

(B) REQUIREMENTS.—The assessment under subparagraph (A) shall—

(i) include data on carbon storage potential and climate resilience, including—

(I) safety for local communities;

(II) avoiding negative environmental impacts; and

(III) identifying regions with lower risks of reversing carbon dioxide removal practices over time; and

(ii) identify economic development opportunities for local communities.

(3) OTHER ACTIVITIES.—The Assistant Secretary shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Secretary of the Interior.

(4) CONSULTATION.—The Assistant Secretary shall carry out the activities described in this section in consultation with—

(A) the Secretary of Agriculture;

(B) the Secretary of Energy; and

(C) the Chief of the Forest Service.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary of the Interior to carry out this section $2,000,000 for each of fiscal years 2024 through 2033.

TITLE VI—DEPARTMENT OF TRANSPORTATION

SEC. 601. FEDERAL HIGHWAY ADMINISTRATION.

(a) DEFINITIONS.—In this section:

(1) CARBON-SEQUESTERING NEW MATERIAL.—The term ''carbon-sequestering new material'' means a novel formulation of cement, concrete, or aggregate that allows captured carbon dioxide to be sequestered, including—

(A) carbon dioxide-adsorbing materials;

(B) carbon dioxide-absorbing materials;

(C) carbon dioxide-cured cement and concrete;

(D) new aggregate materials made from mineral carbonization;

(E) cement formulations that substitute clinker with other materials, subject to the condition that such other materials comprise not less than 50 percent of the cement formulation; and

(F) additional materials as designated by the Secretary.

(2) PROGRAM.—The term ''program'' means the research, development, and demonstration program established under subsection (b).

(3) SECRETARY.—The term ''Secretary'' means the Secretary of Transportation.

(b) ESTABLISHMENT.—The Secretary shall establish a program to carry out research, development, and demonstration activities for the use of carbon-sequestering new materials to lower the carbon impact of highway construction materials and public transportation construction materials.

(c) ACTIVITIES.—

(1) DEVELOPMENT AND DEPLOYMENT.—

(A) IN GENERAL.—In carrying out the program, the Secretary shall carry out research on mineral carbonation for use in carbon-sequestering new materials.

(B) CONSIDERATION.—The research under subparagraph (A) shall be informed by the recommendations of the National Academies of Science, Engineering, and Medicine in chapter 11 of the consensus study report entitled ''Gaseous Carbon Waste Streams Utilization: Status and Research Needs'' and published in 2019.

(2) RESEARCH.—

(A) IN GENERAL.—In carrying out the program, the Secretary, in coordination with standard-setting organizations, such as the American Association of State Highway and Transportation Officials, shall carry out research—

(i) on the durability, strength, and stability of carbon-sequestering new materials; and

(ii) to support the development of the necessary standards required for the use of carbon-sequestering new materials.

(B) STANDARDS.—Based on the results of the research under subparagraph (A), the Secretary shall coordinate and consult with other necessary governmental and nongovernmental entities, including the entities described in subparagraph (A), to support the development of standards for the use of carbon-sequestering new materials.

(3) GRANTS FOR STATE STANDARDS.—In carrying out the program, the Secretary shall provide grants to a geographically diverse set of States to assist those States in adopting State standards for the procurement of carbon-sequestering new materials in highway and public transportation construction.

(4) LIFECYCLE ASSESSMENTS.—In carrying out the program, the Secretary shall carry out lifecycle assessments of the greenhouse gas emissions associated with carbon-sequestering new materials.

(5) COORDINATION.—The Secretary shall coordinate with—

(A) the Secretary of Energy in carrying out paragraph (1);

(B) the Administrator of the Environmental Protection Agency in carrying out paragraph (4); and

(C) other Federal agencies as necessary to carry out the activities described in this subsection.

(d) GRANT PROGRAM.—

(1) IN GENERAL.—Not later than 2 years after the date of enactment of this Act, the Secretary shall establish a program to provide grants to eligible entities to assist those entities in procuring carbon-sequestering new materials for eligible uses described in paragraph (4).

(2) ELIGIBLE ENTITIES.—An entity eligible to receive a grant under this subsection is—

(A) a State;

(B) a federally recognized Indian Tribe; or

(C) a unit of local government.

(3) APPLICATIONS.—To be eligible to receive a grant under this subsection, an eligible entity shall submit to the Secretary an application at such time, in such manner, and containing such information as the Secretary determines to be appropriate.

(4) USE OF FUNDS.—An eligible entity may use a grant under this subsection to procure and use carbon-sequestering new materials for—

(A) a highway or bridge project eligible for assistance under title 23, United States Code;

(B) a public transportation project eligible for assistance under chapter 53 of title 49, United States Code; and

(C) any other transportation infrastructure project as the Secretary determines to be appropriate.

(5) REQUIREMENTS.—

(A) HIGHWAY OR BRIDGE PROJECTS.—A project described in paragraph (4)(A) shall be subject to the requirements under title 23, United States Code, that would apply if the project was carried out under that title.

(B) PUBLIC TRANSPORTATION PROJECTS.—A project described in paragraph (4)(B) shall be subject to the requirements under chapter 53 of title 49, United States Code, that would apply if the project was carried out under that chapter.

(e) FUNDING.—

(1) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary to carry out this section—

(A) $32,000,000 for fiscal year 2024;

(B) $57,000,000 for fiscal year 2025;

(C) $62,000,000 for fiscal year 2026;

(D) $67,000,000 for fiscal year 2027; and

(E) $72,000,000 for each of fiscal years 2028 through 2033.

(2) ALLOCATION.—

(A) RESEARCH AND DEVELOPMENT.—Of the amounts made available under paragraph (1) for each fiscal year—

(i) $10,000,000 shall be for research under subsection (c)(1);

(ii) $10,000,000 shall be for research under subsection (c)(2);

(iii) $10,000,000 shall be for grants for States under subsection (c)(3); and

(iv) $2,000,000 shall be for lifecycle assessments under subsection (c)(4).

(B) GRANT PROGRAM.—Of the amounts made available under paragraph (1), the Secretary shall use to carry out the grant program under subsection (d)—

(i) $25,000,000 for fiscal year 2025;

(ii) $30,000,000 for fiscal year 2026;

(iii) $35,000,000 for fiscal year 2027; and

(iv) $40,000,000 for each of fiscal years 2028 through 2033.

(3) TREATMENT.—Amounts made available under paragraph (1) shall be available for obligation in the same manner as if those amounts were apportioned under chapter 1 of title 23, United States Code.

TITLE VII—ENVIRONMENTAL PROTECTION AGENCY

SEC. 701. OFFICE OF RESEARCH AND DEVELOPMENT.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Administrator of the Environmental Protection Agency, acting through the Assistant Administrator of Research and Development (referred to in this section as the ''Assistant Administrator''), shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) DIRECT AIR CAPTURE ENVIRONMENTAL IMPACTS.—The Assistant Administrator shall carry out

a lifecycle assessment of the environmental impacts of direct air capture, including—

(A) greenhouse gas emissions;

(B) air and water pollutants;

(C) water use; and

(D) land use.

(3) PRESERVATION OF HARVESTED WOOD.—

(A) IN GENERAL.—The Assistant Administrator shall design and conduct a demonstration of landfills for woody biomass disposal and carbon storage;

(B) COLLABORATION.—The Assistant Administrator shall carry out the activities described in subparagraph (A) in collaboration with the Chief of the Forest Service.

(4) ENVIRONMENTAL AND SOCIAL IMPACTS OF MINERALIZATION.—

(A) IN GENERAL.—The Assistant Administrator shall conduct research on the environmental impacts of mineralization, including broadcasting materials, disturbing piles of mine tailings, and expanded mining activities.

(B) COLLABORATION.—The Assistant Administrator shall carry out the activities de-

scribed in subparagraph (A) in collaboration with—

(i) the Director of the National Science Foundation;

(ii) the Director of the United States Geological Survey; and

(iii) the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy.

(5) RESEARCH ON DECISION SCIENCE.—

(A) IN GENERAL.—The Assistant Administrator shall conduct research on decision science, social impacts, and public engagement on carbon dioxide removal technologies and methods.

(B) COLLABORATION.—The Assistant Administrator shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Director of the National Science Foundation; and

(ii) the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy.

(6) ENVIRONMENTAL AND SOCIAL IMPACTS OF BIOMASS USE IN CARBON DIOXIDE REMOVAL TECHNOLOGIES.—

(A) IN GENERAL.—The Assistant Administrator shall carry out a life cycle analysis of the impact of biomass use in carbon dioxide removal technologies, including—

(i) emissions sequestered in materials;

(ii) emissions impacts of biomass harvest, processing, and transportation;

(iii) unintended disturbances to ecosystem carbon stocks;

(iv) indirect land-use change; and

(v) alternative fates of biomass used.

(B) CONSIDERATION.—In carrying out the analysis under subparagraph (A), the Assistant Administrator shall consider the social impacts of air pollution relating to biofuel and biomass combustion.

(C) COLLABORATION.—The Assistant Administrator shall carry out the activities described in subparagraphs (A) and (B) in collaboration with the Assistant Secretary for Energy Efficiency and Renewable Energy of the Department of Energy.

(7) LIFECYCLE ASSESSMENT AND MONITORING FOR MINERALIZATION.—The Assistant Administrator shall carry out a technoeconomic and lifecycle assessment of various mineralization pathways and research on protocols for monitoring and verification of carbon removed or sequestered through mineralization.

(8) OTHER ACTIVITIES.—The Assistant Administrator shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Administrator of the Environmental Protection Agency.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Administrator of the Environmental Protection Agency to carry out this section—

(1) $24,000,000 for fiscal year 2024;

(2) $28,000,000 for fiscal year 2025;

(3) $35,000,000 for fiscal year 2026;

(4) $32,000,000 for each of fiscal years 2027 and 2028;

(5) $34,000,000 for each of fiscal years 2029 and 2030;

(6) $31,000,000 for each of fiscal years 2031 and 2032; and

(7) $30,000,000 for fiscal year 2033.

TITLE VIII—NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SEC. 801. EARTH SCIENCE DIVISION PROGRAM.

(a) RESEARCH, DEVELOPMENT, AND DEMONSTRATION.—

(1) IN GENERAL.—The Administrator of the National Aeronautics and Space Administration (referred to in this section as the ''Administrator'') shall carry out research, development, and demonstration activities in each of the areas described in this subsection.

(2) ABOVEGROUND CARBON MONITORING.—The Administrator shall carry out a long-term collection of continuous spaceborne LiDAR data to measure and track carbon stocks and carbon cycling in aboveground biomass, through extension of the Global Ecosystem Dynamics Investigation mission, or through other missions with similar or improved capacity.

(3) RESOURCE ASSESSMENT.—

(A) IN GENERAL.—The Administrator shall carry out mapping and evaluation of

coastal marine ecosystems for carbon dioxide removal potential, including—

(i) wetlands;

(ii) peatlands; and

(iii) seagrass beds.

(B) COLLABORATION.—The Administrator shall carry out the activities described in subparagraph (A) in collaboration with the Administrator of the National Oceanic and Atmospheric Administration.

(4) OTHER ACTIVITIES.—The Administrator shall carry out other carbon dioxide removal research, development, and demonstration activities, as determined by the Administrator.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Administrator to carry out this section—

(1) $53,000,000 for each of fiscal years 2024 and 2025; and

(2) $8,000,000 for each of fiscal years 2026 through 2033.

TITLE IX—NATIONAL SCIENCE FOUNDATION

SEC. 901. DIRECTORATE FOR BIOLOGICAL SCIENCES.

(a) RESEARCH.—

(1) IN GENERAL.—The Director of the National Science Foundation (referred to in this section as the ''Director'') shall award funding for research activities in each of the areas described in this subsection.

(2) GENETIC MODELING AND TOOLS.—

(A) IN GENERAL.—The Director shall award funding for research to improve carbon dioxide uptake and conversion through genetic manipulation of biological materials for carbon dioxide removal and utilization and research on the potential ecological impacts of those improvements.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Director of the Office of Science of the Department of Energy;

(ii) the Secretary of Agriculture; and

(iii) the Administrator of the Environmental Protection Agency.

(3) OTHER RESEARCH.—The Director shall award funding for other carbon dioxide removal research, as determined by the Director of the National Science Foundation.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Director to carry out this section—

(1) $2,000,000 for fiscal year 2024;

(2) $3,000,000 for fiscal year 2025; and

(3) $5,000,000 for each of fiscal years 2026 through 2033.

SEC. 902. DIRECTORATE FOR ENGINEERING.

(a) RESEARCH.—

(1) IN GENERAL.—The Director of the National Science Foundation (referred to in this section as the ''Director'') shall award funding for research activities in each of the following areas described in this subsection.

(2) INTEGRATED PROCESS DESIGN.—

(A) IN GENERAL.—The Director shall award funding for research and development on the integration of carbonation with carbon dioxide capture processes.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy.

(3) OTHER RESEARCH.—The Director shall award funding for other carbon dioxide removal research, as determined by the Director.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Director to carry out this section—

(1) $2,000,000 for fiscal year 2024; and

(2) $3,000,000 for each of fiscal years 2025 through 2033.

SEC. 903. DIRECTORATE FOR GEOSCIENCES.

(a) RESEARCH.—

(1) IN GENERAL.—The Director of the National Science Foundation (referred to in this section as the ''Director'') shall award funding for research activities in each of the following areas described in this subsection.

(2) SOIL CARBON.—

(A) IN GENERAL.—The Director shall award funding for fundamental research on plant-root-fungi interactions, deep inversion of soils, and other topics with the potential to advance carbon dioxide removal.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Director of the Office of Science of the Department of Energy; and

(ii) the Administrator of the Agricultural Research Service.

(3) MODELING AND PREDICTIVE TOOL DEVELOPMENT.—

(A) IN GENERAL.—The Director shall award funding for research to improve existing carbon sequestration modeling tools and the development of simulation-based tools to predict and quantify soil carbon sequestration.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Administrator of the Agricultural Research Service; and

(ii) the heads of other offices in the Department of Agriculture, as determined by the Secretary of Agriculture.

(4) CARBON MINERALIZATION.—

(A) IN GENERAL.—The Director shall award funding for fundamental research on mineralization kinetics, geomechanics, rock physics, and utilization-oriented carbonation

with the potential to advance carbon dioxide removal.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Director of the Office of Science of the Department of Energy.

(5) PILOT STUDIES OF IN SITU MINERALIZATION.—

(A) IN GENERAL.—The Director shall award funding for field drilling and injection in reactive formations (including peridotite and basalt) to advance understanding of carbon mineralization.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy.

(6) ENVIRONMENTAL AND SOCIAL IMPACTS OF EXPANDED MINING FOR MINERALIZATION.—

(A) IN GENERAL.—The Director shall award funding for research on the environmental and social impacts of expanded mining

activities for the purpose of mineralization, including net carbon impact.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Director of the United States Geological Survey;

(ii) the Assistant Administrator for Research and Development of the Environmental Protection Agency; and

(iii) the Assistant Secretary for Office of Fossil Energy and Carbon Management of the Department of Energy.

(7) COASTAL MARINE CARBON FUNDAMENTAL RESEARCH.—

(A) IN GENERAL.—The Director shall award funding for fundamental research on coastal ecosystem carbon dioxide sequestration.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Administrator of the National Oceanic and Atmospheric Administration.

(8) OCEAN ALKALINITY.—

(A) IN GENERAL.—The Director shall award funding for fundamental and applied research on techniques for and impacts of artificial modification of ocean alkalinity, including limited-scale experiments on alkalinity enhancement techniques at sea, designed and monitored to avoid impacts beyond the zone of the experiment and within internationally recognized frameworks.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Director of the Office of Science of the Department of Energy; and

(ii) the Administrator of the National Oceanic and Atmospheric Administration.

(9) OCEAN FERTILIZATION FUNDAMENTAL RESEARCH.—

(A) IN GENERAL.—The Director shall award funding for fundamental research and modeling on the impacts and effectiveness of ocean iron fertilization and nitrogen and phosphorous fertilization research.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Director of the Office of Science of the Department of Energy; and

(ii) the Administrator of the National Oceanic and Atmospheric Administration.

(10) ARTIFICIAL OCEAN IRON FERTILIZATION.—

(A) IN GENERAL.—The Director shall award funding for limited-scale experiments to stimulate and measure large phytoplankton blooms, designed and monitored to avoid impacts beyond the zone of the experiment and within internationally recognized frameworks.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Administrator of the National Oceanic and Atmospheric Administration.

(11) ARTIFICIAL OCEAN MACRONUTRIENT FERTILIZATION.—

(A) IN GENERAL.—The Director shall award funding for limited-scale experiments on ocean macronutrient fertilization, designed and

monitored to avoid impacts beyond the zone of the experiment and within internationally recognized frameworks.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Administrator of the National Oceanic and Atmospheric Administration.

(12) OTHER RESEARCH.—The Director shall award funding for other carbon dioxide removal research, as determined by the Director.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Director to carry out this section—

(1) $21,000,000 for fiscal year 2024;

(2) $34,000,000 for fiscal year 2025;

(3) $61,000,000 for fiscal year 2026;

(4) $73,000,000 for each of fiscal years 2027 and 2028;

(5) $68,000,000 for each of fiscal years 2029 and 2030;

(6) $65,000,000 for fiscal year 2031; and

(7) $60,000,000 for each of fiscal years 2032 and 2033.

SEC. 904. DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES.

(a) RESEARCH.—

(1) IN GENERAL.—The Director of the National Science Foundation (referred to in this section as the ''Director'') shall award funding for research activities in each of the following areas described in this subsection.

(2) NSF ENGINEERING RESEARCH CENTER.—The Director shall establish a new National Science Foundation Engineering Research Center focused on materials research and early-stage application of sorbents, solvents, membranes, and related direct air capture components.

(3) DIRECT AIR CAPTURE MATERIALS RESEARCH.—The Director shall award funding for materials research on sorbents, solvents, membranes, and related direct air capture components.

(4) CARBONATION.—

(A) IN GENERAL.—The Director shall award funding for research to control carbonation reactions, accelerate carbonation, and understand structure-property relationships.

(B) COLLABORATION.—The Director shall carry out the activities described in subpara-

graph (A) in collaboration with the Director of the Office of Science of the Department of Energy.

(5) CATALYSTS.—

(A) IN GENERAL.—The Director shall award funding for research on impurity-tolerant catalyst development, coupled reduction and oxidation reactions, and reduced additives.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Director of the Office of Science of the Department of Energy.

(6) NEW MATERIALS DEVELOPMENT AND APPLICATIONS.—

(A) IN GENERAL.—The Director shall award funding for development of new materials for capturing and utilizing carbon dioxide, including materials with carbon-carbon bonds.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Director of the Office of Science of the Department of Energy.

(7) OTHER RESEARCH.—The Director shall award funding for other carbon dioxide removal research, as determined by the Director.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Director to carry out this section—

(1) $11,000,000 for fiscal year 2024;

(2) $28,000,000 for fiscal year 2025;

(3) $32,000,000 for each of fiscal years 2026 and 2027;

(4) $38,000,000 for each of fiscal years 2028 and 2029;

(5) $33,000,000 for fiscal year 2030;

(6) $28,000,000 for fiscal year 2031;

(7) $23,000,000 for fiscal year 2032; and

(8) $18,000,000 for fiscal year 2033.

SEC. 905. DIRECTORATE FOR SOCIAL, BEHAVIORAL, AND ECONOMIC SCIENCES.

(a) RESEARCH.—

(1) IN GENERAL.—The Director of the National Science Foundation (referred to in this section as the ''Director'') shall award funding for research activities in each of the following areas described in this subsection.

(2) INTEGRATED ASSESSMENT MODELING AND GRASSLANDS AND FOREST IMPACTS MODELING.—

(A) IN GENERAL.—The Director shall award funding for technical, economic, and social modeling of impacts on land use from avoided conversion of grasslands and forests, reforestation, conservation, afforestation, and forest management changes.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with the Secretary of Agriculture.

(3) INTEGRATED ASSESSMENT MODELING AND DIRECT AIR CAPTURE IMPACTS MODELING.—The Director shall award funding for technical, economic, and social modeling of impacts on land and energy use from direct air capture, including future electricity grid mix scenarios.

(4) ETHICAL, LEGAL, AND SOCIAL IMPACTS OF BIOTECHNOLOGY.—The Director shall award funding for research on the ethical, legal, and social implications of biotechnology use in carbon dioxide removal.

(5) GOVERNANCE FRAMEWORKS.—The Director shall award funding for research into governance

frameworks for safe and sustainable experimentation with ocean-based carbon dioxide removal.

(6) OTHER RESEARCH.—The Director shall award funding for other carbon dioxide removal research, as determined by the Director.

(b) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to the Director to carry out this section $12,000,000 for each of fiscal years 2024 through 2033.

SEC. 906. DIVISION OF SOCIAL AND ECONOMIC SCIENCES.

(a) RESEARCH.—

(1) IN GENERAL.—The Director of the National Science Foundation (referred to in this section as the ''Director'') shall award funding for research activities in each of the following areas described in this subsection.

(2) RESEARCH ON DECISION SCIENCE.—

(A) IN GENERAL.—The Director shall award funding for research on decision science, social impacts, and public engagement relating to carbon dioxide removal technologies and methods.

(B) COLLABORATION.—The Director shall carry out the activities described in subparagraph (A) in collaboration with—

(i) the Assistant Administrator for Research and Development of the Environmental Protection Agency; and

(ii) the Assistant Secretary for Fossil Energy and Carbon Management of the Department of Energy.

(3) OTHER RESEARCH.—The Director shall award funding for other carbon dioxide removal research, as determined by the Director.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Director to carry out this section—

(1) $2,000,000 for fiscal year 2024;

(2) $4,000,000 for each of fiscal years 2025 through 2028; and

(3) $5,000,000 for each of fiscal years 2029 through 2033.

TITLE X—OTHER MATTERS

SEC. 1001. PLAN FOR INTERNATIONAL COLLABORATION.

(a) IN GENERAL.—The Director of the Office of Science and Technology Policy shall establish a plan for international coordination on research, development, and demonstration projects for carbon dioxide removal.

(b) COORDINATION.—In carrying out subsection (a), the Director of the Office of Science and Technology Policy shall coordinate with—

(1) the Secretary of State; and

(2) the Secretary of Energy.

○