<u>EXHIBIT BB</u>

YALE UNIVERSITY

"Our problems are man-made. Therefore, they can be solved by man." – John F. Kennedy

NATURAL CARBON SOLUTIONS FUND

A proposal to support the Natural Carbon Capture Center prepared for the Audi CO2 Cy Pres Settlement Fund

EXECUTIVE SUMMARY

At Yale, we are advancing solutions to climate change through our Planetary Solutions Project – a university-wide initiative that seeks to solve global environmental problems caused by human activities, especially climate change and loss of biological diversity. Scientists and engineers across multiple disciplines are working to discover transformative and scalable alternatives for renewable energy; advance carbon capture and storage strategies to remove CO_2 from our atmosphere; and stem the destruction of vulnerable ecosystems.

The proposal highlights several technological solutions that are inspired by natural processes, including artificial photosynthesis; solar fuels; and carbon capture and utilization. These technologies have the potential to end our dependence on fossil fuels and reduce the amount of carbon in our atmosphere while our global economies continue to grow and our standards of living continue to rise. The speed in which these ground-breaking technologies are translated into the world are buoyed by strategic research investments made possible through a Natural Carbon Solutions Fund. Our proposed $5 million budget (further depicted in Appendix C) comprises $1 million of immediate-use, fully expendable funds for research projects in the areas mentioned above, and $4 million of endowed funds for sustained support of additional research. The faster the research is activated within the Planetary Solutions Project the better but specific payment timeline is flexible. This research will be based on natural models to foster technological innovations and discoveries that will provide practical solutions to the challenges of climate change, and help humanity achieve our balance with nature.

INTRODUCTION

Human ingenuity has vastly improved the quality of life for people across the planet. Our societies now have access to clean water, energy for heating and electricity, global transportation and communication, agricultural innovations, and advanced medical care—all of which have lengthened life span and improved well-being over the last two centuries. However, these advances have had unintended consequences, including emissions of greenhouse gases that are causing extreme climate change—melting glaciers and polar ice, rising sea levels, prolonged droughts, massive wildfires, excessive heat waves, proliferation of diseases, and more. These catastrophic consequences will continue to escalate unless we reduce or reverse greenhouse gas emissions.

At Yale, we believe that human ingenuity can also provide planetary solutions and achieve humanity's balance with nature. We recently established the Yale Center for Natural Carbon Capture, which will focus on natural processes to sequester carbon dioxide (CO_2) from our atmosphere through advances in ecosystem science, geological storage and natural models for renewable energy, and carbon capture and carbon utilization. This center, supported recently with a $100 million dollar gift from FedEx, is a key part of Yale's Planetary Solutions Project, a university-wide initiative that seeks to solve global environmental problems caused by human activities, especially climate change and loss of biological diversity. Planetary solutions developed at Yale will integrate the natural and social sciences; be disseminated through education, outreach, and civic leadership; and be supported by incentives and policies to promote their implementation. Appendices A and B demonstrate the reach of faculty and initiatives addressing planetary solutions.

NATURE AS A MODEL

Yale-Myers Forest

Our planet has a natural carbon cycle that circulates CO_2 with processes such as photosynthesis, plant and animal respiration, geological activity, and atmospheric-oceanic exchange. Fossil fuel emissions disrupt the natural carbon cycle and cause the atmosphere to absorb increasing amounts of CO_2 each year, leading to global warming.

Yale scientists are advancing the frontiers of artificial photosynthesis to design systems that may convert sunlight into "solar fuels." Modeling geological carbon capture is another innovative approach to developing carbon-based materials for industry and building construction. For example, production of cement currently contributes a substantial amount of carbon to the atmosphere, but it can also be engineered to absorb CO_2 in a manner similar to natural geological processes, which can be used to approach zero-carbon cement production. There are numerous large-scale applications that will benefit from scientific and technological advances in capturing and converting CO_2 including liquid fuels, consumer products, and building materials.

Artificial Photosynthesis

Gary Brudvig, Benjamin Silliman Professor of Chemistry, Director of the Yale Energy Sciences Institute (right)

The sun delivers more energy to the surface of the earth in one hour than the total energy consumed by humans in an entire year. By harnessing solar energy, we can end our dependence on fossil fuels and eliminate or even reverse greenhouse gas emissions. While current technologies such as solar panels hold great promise, they are intermittent and unreliable at night and during cloudy days. Consequently, technological innovation is necessary to store solar energy for continuous reliability and robust applications such as utilities and transportation.

Plants use photosynthesis to convert solar energy and produce high-energy carbohydrates, such as glucose, which they use to feed their energy needs. During this natural process, enzymes help plants split water into its constituent elements – hydrogen and oxygen – which are then combined with CO_2 to form carbohydrates. ***At Yale, scientists are designing low-cost, highly***

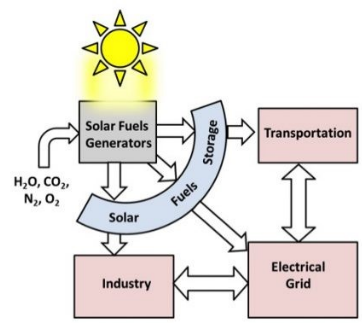
efficient catalysts that work like natural enzymes to split water into hydrogen and oxygen. These elements may be used to form carbon-neutral fuels that may be stored, transported, and used as sustainable alternatives to fossil fuels.

Solar Fuels

Hydrogen Fuel

California's "hydrogen highway" is the nation's first network of hydrogen fuel stations for passenger vehicles. This network has the potential to play a key role in achieving the state's ambitious goal of 100% zero-emission new vehicles by 2035. However, the current cost of hydrogen fuel is relatively high in comparison to gasoline, and the current source of hydrogen fuel is primarily steam reforming of natural gas, which also produces CO_2 as an emission.

By harnessing solar power and artificial photosynthesis, hydrogen fuel can be produced as a low-cost, energy efficient "solar fuel." Rather than using natural gas to produce hydrogen with CO_2 as an emission, water can be split into hydrogen with oxygen as an emission. Solar energy can be used for this process, and low-cost catalysts can reduce the cost of production.
Yale scientists are also working to design other solar fuels, such as ethanol and ammonia, that utilize CO_2 captured from the atmosphere or industrial emissions.



Yale is one of six institutions within the Department of Energy's Center for Hybrid Approaches in Solar Energy to Liquid Fuels (CHASE). The CHASE team at ***Yale will focus on developing systems for using sunlight and water to convert CO_2 and nitrogen into liquid fuels.***

Solar fuels can be used to store and release energy in a similar fashion to fossil fuels. Generating fuels from sunlight is valuable because the sun is our largest sustainable source of energy. Over the last two decades, society has made enormous progress in converting sunlight to electricity, but electricity cannot be stored on a large enough scale for many important applications. Therefore, there is a need for renewable solar fuels, especially liquids that can be utilized with our current infrastructure, to replace fossil fuels.

Carbon Capture and Utilization

The rising level of CO_2 in our atmosphere represents an existential threat to society. Urgent action is needed to develop new technologies that limit carbon dioxide emissions and reduce levels of carbon dioxide in our atmosphere. One strategy to achieve to this goal is CO_2 storage, in which CO_2 is captured and stored underground. A complementary strategy is CO_2 carbon dioxide utilization, in which CO_2 is used as a feedstock to make more valuable products. Rather than producing fuels and building materials and plastics from fossil fuel-based feedstocks, they may instead be produced from captured CO_2. The potential impact of this technology is immense. A recent study estimated that the market for products from carbon dioxide utilization could be as high as $800 billion by the end of the decade, which would utilize a minimum of 7 billion metric tons of CO_2 per year. This is expected to increase even further in future years and provides tremendous economic and policy incentives for capturing carbon from our atmosphere and industrial emissions.

Plastics, polymers, and other novel materials have great potential to sequester significant amounts of CO_2. Storing carbon in these materials results in valuable products that can be used in everything from pipes to packaging. ***Yale scientists are working to design a wide array of novel polymers that incorporate CO_2 in significant quantities, provide high functional performance, and are environmentally friendly.*** These materials can be designed to achieve long-term storage of carbon, or can be reused or recycled, and are degradable.

The production of carbonates from industrial waste, including slag from iron production, has also been shown to have considerable promise for capturing carbon and follows many of the same chemical processes found in natural geological weathering. Enhancing these processes would greatly increase our ability to capture and store carbon in the industrial sector.

The production of cement is a significant contributor to atmospheric CO_2 emissions since it involves the heating of natural carbonates (limestone) to make the binder, or "clinker." This both reverses the geological storage of carbon and emits CO_2 through the heating process. Yale scientists and engineers are drawing insights from nature and using geological or biologic models to transform CO_2 to develop new useful materials through catalytic and other novel processes.

Cement Cured with CO_2

OPPORTUNITY FOR SUPPORT

At Yale, we believe that planetary-scale problems require planetary solutions, and that human ingenuity, leadership, and cooperation can solve the challenges of climate change to achieve humanity's balance with nature. The Planetary Solutions Project will bring to bear the full weight of Yale's strengths—spanning natural sciences, engineering, social sciences, humanities, education, communication, law, and business—to achieve three major goals: mitigate global warming and environmental concerns, adapt to a changing planet, and engage individuals, organizations, and governments to facilitate action.

A generous contribution of $5 million would establish a Natural Carbon Solutions Fund at Yale, which may be divided into current-use funds ($1 million) for immediate, high-impact research and an endowment ($4 million) to provide sustained support for natural carbon solutions research.

These technical innovation funds will be deployed from the Provost's Office for Research to support Yale's scientists and engineers across multiple disciplines to discover transformative and scalable alternatives for renewable energy; advance carbon capture and storage strategies to remove CO_2 from our atmosphere; and utilize captured CO_2 in fuels, building materials, and industrial and consumer products. Endowed funds will be invested in accordance with the university's general endowment policies, and payout from endowed funds will be used to provide sustained support for natural carbon solutions research through direct research support or by supporting post-doctoral or doctoral students in associated labs.

Thank you for placing your confidence in Yale's ability to solve pressing climate challenges and develop novel technical solutions in carbon capture. We look forward to deploying these resources via Yale's Natural Carbon Capture Center, along with our other industrial and corporate partners.

For more information, please contact:

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APPENDIX A – YALE PLANETARY SOLUTIONS ECOSYTEM

Breadth of Planetary Solutions at Yale

Climate change is a grand challenge and extremely broad in scope. Addressing it will require an approach from all angles, including scientific research and engineered solutions; efforts to understand and mitigate its effects on health; education and outreach; persistent action; the implementation of sound policy; and an awareness of how the changing planet is affecting society and humanity. Yale has strength in each of these areas, and groups throughout campus are tackling each component of this unprecedented challenge.

Planetary Solutions Project

Innovation
School of Engineering and Applied Science
Center for Green Chemistry and Green Engineering
Energy Sciences Institute

Environmental and Planetary Research
School of the Environment
Department of Earth and Planetary Sciences
Department of Ecology and Evolutionary Biology
Department of Chemistry
Department of Statistics and Data Science
Institute for Biospheric Studies
Tropical Resources Institute
Center for Earth Observation
Microbial Sciences Institute

Society and Humanity
Center for Industrial Ecology
Hixon Center for Urban Ecology
School of Architecture
Program in Agrarian Studies
Franke Program in Science and the Humanities
Environmental Humanities
Center for Ecosystems and Architecture
MacMillan Center
Forum on Religion and Ecology at Yale
History of Science and Medicine Program
Literature, the Arts, and the Environment Colloquium
SAGE Magazine
Whitney Humanities Center
Environmental History at Yale
Sustainable Food Program
Department of Anthropology
Yale Divinity School

Action and Policy
Carbon Containment Lab
Carbon Charge Project
The Forests Dialogue
TSAI Center for Innovative Thinking at Yale
Kerry Initiative
Environmental Dialogue
School of Management
Jackson Institute for Global Affairs
Center for Business and the Environment
Forest Forum
Center for Environmental Law and Policy
Urban Resources Initiative
Sustainability Enabled Exploration
School of Law
Department of Economics
Department of Political Science

Outreach and Education
Program in Climate Change Communication
e360 Magazine
Peabody Museum of Natural History
Yale Environmental Film Festival
Climate Connections
The School Forests
Environmental Leadership and Training Initiative
Ucross High Plains Stewardship Initiative

Health
School of Public Health
School of Medicine
School of Nursing
Institute for Global Health
Center for Climate Change and Health
Solutions for Energy, Air, Climate, and Health Center
Center for Perinatal, Pediatric, and Environmental Epidemiology

APPENDIX B – REPRESENTATIVE FACULTY

Policy, Diplomacy and Economics

- William Nordhaus ’63, ’72 MA, *Sterling Professor of Economics and Professor of Forestry and Environmental Studies,* was awarded the Nobel Prize in 2018 for integrating climate change into long-run macroeconomic analysis;

- John Kerry ’66, *Special Presidential Envoy for Climate, Distinguished Fellow for Global Affairs and leader of the Kerry Initiative at the Jackson Institute for Global Affairs*, was a key architect of the Paris Agreement;
- Susan Biniaz ’80, *former State Department Deputy Legal Adviser, Senior Fellow at the Jackson Institute for Global Affairs,* was the lead climate lawyer and a climate negotiator for the Paris Agreement. Biniaz is also a Senior Fellow at the UN Foundation, a Senior Advisor at the Center for Climate and Energy Solutions, and a Distinguished Senior Fellow at Climate Advisers;
- Dan Esty ’86 JD, *Hillhouse Professor, Director of the Yale Center for Environmental Law and Policy and Co-Director of the Yale Initiative on Sustainable Finance,* served as Commissioner of Connecticut’s Department of Energy and Environmental Protection and in senior positions at the Environmental Protection Agency, where he helped to manage the agency’s regulatory programs and negotiate the 1992 UN Framework Convention on Climate Change;
- Marian Chertow ’81 MPPM, ’00 PhD, *Associate Professor of Industrial Environmental Management*, was inducted into the Connecticut Women’s Hall of Fame for her longtime commitment to environmental innovation.

Ecology and Environment

- Ingrid C. “Indy” Burke, *Carl W. Knobloch, Jr. Dean at the Yale School of the Environment,* is an internationally respected ecosystem ecologist whose work has focused on carbon and nitrogen cycling in semi-arid rangeland ecosystems and the effects of land management and climate variability on these systems;
- Mark Ashton, *Morris K. Jesup Professor of Silviculture and Forest Ecology, School of the Environment*
- Liza Comita, *Associate Professor of Tropical Forest Ecology, School of the Environment, Co-Director Natural Carbon Capture Center*
- Mark Bradford, *Professor of Soils and Ecosystem Ecology, School of the Environment*
- Xuhui Lee, *Sara Shallenberger Brown Professor in the Yale School of the Environment*
- William Lauenroth, *Professor in the Yale School of the Environment*
- Peter Raymond, *Professor of Ecosystem Ecology, School of the Environment*

Environmental Justice and Health

- Dorceta Taylor, *Professor of Environmental Justice,* is a leading expert in the field of institutional diversity and workforce dynamics in the environmental sector. Taylor's research interests also include urban agriculture, food access, and food insecurity;
- Paul Anastas, *Teresa and H. John Heinz III Professor of Chemistry for the Environment, School of the Environment and School of Public Health*

Energy, Artificial Photosynthesis and Solar Fuels

- Gary Brudvig, *Benjamin Silliman Professor of Chemistry*, *Professor of Molecular Biophysics and Biochemistry*, *and Director of the Yale Energy Sciences Institute*, is a fellow of the American Academy of Arts and Sciences and is investigating artificial photosynthesis for low-cost and scalable alternative energy production, storage, and utilization;
- Sharon Hammes-Schiffer, *John Gamble Kirkwood Professor of Chemistry,* is a member of the National Academy of Sciences and the American Academy of Arts and Sciences. Schiffer received the Royal Society of Chemistry's Bourke Award for theoretical research that has guided the design of catalysts for solar energy storage;
- Robert Crabtree, *Conkey P. Whitehead Professor of Chemistry*
- James Mayer, *Charlotte Fitch-Roberts Professor of Chemistry*
- Victor Batista, *Professor of Chemistry*
- Nilay Hazari, *Professor of Chemistry*
- Patrick Holland, *Professor of Chemistry*
- Hailiang Wang, *Associate Professor of Chemistry,* employs chemistry, materials science, nanotechnology and surface science to tackle the challenges in electrochemical energy storage and conversion. Wang and his team have developed a catalyst that converts carbon dioxide and water into a synthetic fuel;
- Shu Hu, *Assistant Professor of Chemical and Environmental Engineering*

Geology, Earth Systems and Carbon Storage

- David Bercovici, *Frederick W. Beinecke Professor of Geology and Geophysics and Chair of Earth & Planetary Sciences*, is a member of the National Academy of Sciences and the American Academy of Arts and Sciences, and a fellow of the American Geophysical Union. Bercovici's research includes carbon sequestration; *Co-Director Natural Carbon Capture Center*
- Jay Ague, *Henry Barnard Davis Professor of Earth & Planetary Sciences*
- Jun Korenaga, *Professor of Earth & Planetary Sciences*
- Noah Planavsky, *Associate Professor of Earth & Planetary Science*
- Alan Rooney, *Assistant Professor of Earth & Planetary Sciences*
- Pincelli Hull, *Assistant Professor of Earth & Planetary Sciences*

Oceans and Climate Dynamics

- Mary-Louise Timmermans, *Damon Wells Professor of Earth and Planetary Sciences and EPS Director of Undergraduate Studies,* received the President's Early Career Award for Scientists and Engineers and was a U.S. delegate of the Marine Working Group of the International Arctic Science Committee, and a member of the National Research Council Ocean Studies Board Committee on Responding to Oil Spills in Arctic Marine Environments. Timmermans investigates the dynamics and variability of the Arctic Ocean, sea ice, and climate;
- Ruth Blake, *Professor of Earth and Planetary Sciences*, received the F.W. Clarke Award of the Geochemical Society and was a lead scientist aboard the exploration vehicle Nautilus. Blake studies biological and chemical activity in oceans, sediments, and soils;
- Alexey Fedorov, *Professor of Ocean and Atmospheric Sciences,* investigates ocean and climate dynamics in the contexts of contemporary global warming and past climate changes, particularly problems of ocean and atmospheric circulation, ocean thermal structure and variability, large-scale ocean-atmosphere interactions, climate variations on scales ranging from several to thousands of years and longer, and climate predictability.

Plants, Adaptation and Enhanced Photosynthesis

- Michael Donoghue, *Sterling Professor of Ecology and Evolutionary Biology, Director of the Yale Institute for Biospheric Studies, and Curator of Botany at the Peabody Museum of Natural History,* is a member of the National Academy of Sciences and a fellow of the American Academy of Arts and Sciences. Donoghue uses phylogenetics to study the evolution and ecology of plants and their adaptation to climate change;
- Erika Edwards, *Professor of Ecology and Evolutionary Biology, Curator of Botany at the Peabody Museum of Natural History, Director of Marsh Botanical Gardens, and EEB Director of Graduate Studies,* investigates plant diversity and enhanced photosynthesis for food security and carbon sequestration;
- Craig Brodersen, *Associate Professor of Plant Physiological Ecology,* studies the structure and function of plants, with a particular interest in how plants efficiently utilize water and light. Brodersen's research also highlights the implications of environmental conditions that push plants beyond their physiological thresholds;
- Carla Staver, *Associate Professor of Ecology and Evolutionary Biology*

Green Engineering and Water

- Julie Zimmerman, *Senior Associate Dean of Academic Affairs at the School of the Environment, Professor of Engineering & Applied Science, Professor of Forestry & Environmental Studies, and Deputy Director of the Center for Green Chemistry & Green Engineering,* is an internationally recognized engineer whose work is focused on advancing innovations in sustainable technologies, including breakthroughs on the integrated biorefinery, designing safer chemicals and materials, creating novel materials for water purification, and analyzing the water-energy nexus;

- Jaehong Kim, *Henry P. Becton Sr. Professor and Chair of Chemical & Environmental Engineering,* investigates nanomaterials and single atom catalysts for water treatment, advanced materials-based approaches for solar water disinfection, and photocatalytic and electrochemical processes for environmental and energy applications;
- Menachem Elimelech, *Roberto Goizueta Professor of Chemical and Environmental Engineering at the School of Engineering and Applied Science*, has made major strides in clean water research. Elimelech has focused on water desalination technology, improving water and sanitation in developing countries, understanding the environmental implications of nanomaterials, and creating sustainable production of water and energy generation with engineered osmosis;
- James Saiers, *Clifton R. Musser Professor of Hydrology, School of the Environment*

<u>Urbanization and Sustainable Cities</u>

- Karen Seto, *Frederick C. Hixon Professor of Geography and Urbanization Science,* is one of the world's leading experts on contemporary urbanization and global change. Seto is co-leading the urban mitigation chapter for the United Nations Intergovernmental Panel on Climate Change 6th Assessment Report and co-led the same chapter for the IPCC 5th Assessment Report. She is also co-editor-in-chief of the journal, Global Environmental Change;
- Oswald Schmitz, *Oastler Professor of Population and Community Ecology, School of the Environment*

APPENDIX C – BUDGET

Research Area	Time Period	Amount
Artificial Photosynthesis Solar Fuels Carbon Capture and Utilization	Immediate, fully-expendable research grants (approximately 3-5 awards given)	$1 Million Current Use
Nature-Inspired Technological Solutions to Climate Change	Annual faculty research support from Endowed Fund (e.g., laboratory equipment, fellowships, post docs, and supplies)	$4 Million Endowment (once fully funded, will provide approximately $200 Thousand Annually)