



*Educate, engage and advocate with the public  
and policy makers to mitigate climate change to  
protect global security and natural ecosystems*

## **WHITE PAPER**

### **PROPOSED: NATIONAL ARCTIC ICE RESTORATION INITIATIVE (NAIRI) PLAN**

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#### **EXECUTIVE SUMMARY**

*Global warming (GW) is causing a dramatic shrinking in Arctic sea ice, land ice and snow. A National Oceanic and Atmospheric Administration (NOAA) study reports that the Arctic has warmed more than twice as fast as the rest of the planet, due to a phenomenon known as Arctic Amplification. Arctic Amplification also drives the thawing of permafrost releasing irreversible amounts of greenhouse gasses (GHG) from the Arctic land and shallow seabed off the Siberian coast and further accelerates global warming. With loss of sea ice left unchecked, global warming will soon exceed the 2°C target set by the UN International Panel on Climate Change for 2100, resulting in food and water shortages, damage to infrastructures and the environment, mass human migrations, and destabilization of governments, all threatening U.S. national security interests abroad.*

*U.S. national security at home is likewise at risk with extreme weather patterns and sea level rise impacting our agriculture, infrastructure, and economy. The balance of power is also at risk in the Arctic region with the loss of sea ice resulting in Russia, with their fleet of nuclear-powered ice breakers, strengthening their presence for resource exploitation, military operations, shipping, and dominating leadership for cooperation in the region. China is also showing increased presence in the region. In addition, U.S. military installations and facilities in the Arctic are at risk of significant infrastructure damage resulting from thawing permafrost.*

*We believe the U.S. urgently needs a mitigation strategy focused on preservation and restoration of summer Arctic sea ice to prevent the effects of a warming Arctic from reaching a tipping point. This White Paper proposes to the Biden-Harris Administration that the U.S. establish, in the spirit of a coordinated “whole-of-government approach”, a multi-agency effort for an applied R&D program called the “National Arctic Ice Restoration Initiative” (NAIRI). NAIRI is designed to better understand Arctic climate process and develop approaches to mitigate and restore Arctic sea ice. Further, we believe the U.S. should take the lead in developing and coordinating an international response to mitigate Arctic sea-ice loss and its accelerant effect upon GW and the climate change crisis. The DoD identifies GW as a threat multiplier. Doing nothing to stop the continued warming of the Arctic and the devastating consequences to the world, at home, and to our National security is not an option.*

#### **1.0 OVERVIEW**

The principals at “Secure the Future 2100” (<https://securethefuture2100.org/>) respectfully submit this proposal to the Biden-Harris Administration for consideration. Our organization is dedicated to educating, engaging and advocating with the public and policy makers to mitigate climate change to

protect global security and natural ecosystems. Our perspective on the Arctic region is shaped by a deep interest and commitment to preserving and restoring Arctic sea ice, the dramatic and alarming loss of which is amplifying GW and climate change throughout the northern hemisphere and perhaps world-wide. Accordingly, we believe our organization's goals are in alignment with the Biden-Harris Administration commitment in making climate change a whole-of-government approach with a national security and foreign policy priority to slowing down and reversing GW and climate change. We appreciate the opportunity to provide our perspective on research priorities for the Arctic: particularly at a time when the Arctic is in crisis.

This white paper proposes a bold new plan for multiple Federal Agencies to add a major new Arctic Sea Ice restoration R&D initiative to their existing Arctic R&D programs. A fundamental underlying driver behind our proposal is the strong belief that observational science alone is not enough to address the impending climate disaster the world is now facing. Active and focused R&D targeted on possible *mitigation and restoration* strategies to slow GW are now needed. Our proposal first describes *why* the Arctic, including its sea ice in particular, appears to be a critical leveraging element in the rate of GW going forward. The proposal then describes some initial data suggesting there may be safe and reversible ways in which Arctic sea ice could potentially be preserved and possibly restored. If these data are correct, and considerably more research is needed to verify and potentially extend such preliminary findings, then a coordinated effort by multiple Federal Agencies (see below) can play a critical and coordinated role in enabling the U.S. to be at the forefront of a multi-national effort to slow GW thereby buying time for global decarbonization. We propose that the U.S. take the lead in developing and coordinating an international response to mitigate Arctic sea-ice loss and its accelerant effect upon global warming and the climate change crisis.

Put simply, our proposal is for more *action-oriented* basic and applied research to directly address the possibilities of restoring Arctic sea ice to slow global warming. **We strongly recommend that in this time of Arctic crisis the national Biden-Harris Administration climate action plan embrace a more pro-active research agenda, an agenda incorporating the goal of restoring Arctic sea ice to its more historic norm.**

The Arctic's natural environment, its indigenous peoples and flora and fauna are in desperate need of help. Arctic ice loss has reached crisis proportions. Studies have shown that the Arctic sea ice albedo (reflectivity) feedback has become a driver of GW, not merely a consequence of it. In the next five-years **we believe we must lean forward to understand both the science and engineering of safe and effective Arctic sea ice restoration techniques.**

## **2.0 NEEDS STATEMENT**

In summarizing the annual 2020 Arctic Report Card, NOAA stated that "The sustained transformation to a warmer, less frozen and biologically changed Arctic remains clear"<sup>1</sup>. The Arctic has played a central role in keeping the global climate relatively stable throughout human history. GW is upsetting this stability, causing a dramatic reduction in Arctic sea ice, land ice and snow, thereby impacting the local Arctic ecosystem, infrastructure, and the four million populating the region (including indigenous peoples) while amplifying global warming<sup>2</sup>. This loss of ice and snow is increasing the absorption of solar radiation by land and ocean, causing the Arctic to warm more than twice the global average (Arctic amplification), and releasing GHG from the thawing of land and offshore permafrost (with combined reserves of five times the amount of CO<sub>2</sub> equivalent to that in the atmosphere)<sup>3,4,5</sup>. With warming of the Arctic, a number

of feedback loops have been established that enhance Arctic amplification. A sea ice reflectivity feedback loop from heating of the ocean contributes the equivalent of an additional 25% of global CO<sub>2</sub> emissions to the atmosphere (based on anthropogenically derived CO<sub>2</sub> emissions from 1979 to 2008)<sup>6</sup>. Similarly, a land ice/snow reflectivity feedback loop from heating of the land is estimated to contribute an additional 25% equivalent of global CO<sub>2</sub> emissions to the atmosphere<sup>7</sup>.

In addition to a land reflectivity feedback, an accelerating and potentially irreversible permafrost carbon-climate feedback loop may also be underway with the rapid increase of microbial breakdown of ice-age land-based organic matter to methane and CO<sub>2</sub> and the release of methane from the permafrost residing on the shallow east Siberian Arctic Ocean shelf (microbial breakdown of organic matter and melting of methane hydrate)<sup>8,9,10</sup>. A covering of sea ice over the East Siberian Arctic Shelf has historically helped maintain the quantity of methane released but with ice loss the potential of irreversibly releasing large amounts of methane becomes more plausible.<sup>5, 11,12</sup> This phenomenon is still under assessment<sup>7, 11,12</sup>. By mid-century with a business as usual scenario, CO<sub>2</sub> emissions from permafrost during just the winter would rise by 41% and by 2100 the area of near-surface permafrost is expected to decrease by 30–99%, releasing up to as much as 240 gt of GHG to the atmosphere<sup>13,14</sup>. Also, about 20% of Arctic land permafrost is vulnerable to abrupt permafrost thaw producing thermokars lakes as ground subsides<sup>13</sup>: rapidly decomposing organic matter and releasing methane to the atmosphere under moist conditions followed by CO<sub>2</sub> release when dried. Sea ice decline and associated changes in Arctic regional climate are drivers of changes to tundra and boreal forest ecosystems with boreal forests expanding into tundra and differential growth of shrubs in tundra<sup>15,16</sup>. These changes complicate the projection of tundra vegetation in cycling carbon as permafrost degrades (up-take or release of carbon to the atmosphere by vegetation)<sup>16,17</sup>. The rapid decomposition of permafrost is changing the Arctic from a carbon sink to a carbon source and contributes to Arctic amplification and GW<sup>15,18, 19,20</sup>: a scenario that may be slowed with effective mitigation techniques<sup>11,13</sup>. Current and paleoclimate evidence indicates that the disappearance of sea-ice is a driver of this rapid thawing of permafrost<sup>21,22</sup>. Unfortunately, GHG emitted from decomposition of permafrost has not been included or is underestimated in the majority of models used to predict future climates<sup>9, Error! Bookmark not defined.,19,23</sup>. The importance of thawing permafrost was addressed by climate scientists to policymakers during a U.S. State Department conference in 2015<sup>24,25</sup>: also testifying on the severe impact of loss of sea ice to the Arctic, global warming, and national security before the Senate Commerce Science and Technology Committee in 2020<sup>26</sup>. Resolving the loss of Arctic sea ice is imperative to prevent thawing permafrost from reaching a tipping point.

Arctic amplification also impacts atmospheric and ocean circulation patterns, such as modifications of the jet stream and slowing of the Atlantic meridional overturning circulation, causing changes to weather patterns in the Northern Hemisphere and possibly globally<sup>27,28</sup>. Left unchecked, GW will exceed the 2°C target set by the IPCC for 2100, resulting in food and water shortages, damage to infrastructures and the environment, mass human migrations, and destabilization of governments, all threatening U.S. national security interests<sup>29,30,31,32,33,34</sup>. A mitigation strategy is urgently needed to be implemented within this decade to prevent effects of Arctic amplification like permafrost thaw and shift of boreal forests from reaching a tipping point.

### 3.0 OUR PROPOSAL: A MULTI-AGENCY COORDINATED R&D INITIATIVE

We propose, and hope the Biden-Harris Administration will support, the establishment of a focused multiagency R&D program (see below) to develop technologies to restore Arctic sea ice to near historic pre-industrial norms. We further propose that ***NASA take a leadership role in this multiagency initiative.*** NASA is an international leader in studying our home planet. NASA Earth Sciences has contributed a major portion of what we know of our planet through a sustained multi-decadal set of satellite, airborne and ground observations coupled with sophisticated numerical modeling of atmospheric, oceanographic and terrestrial phenomena. *We are proposing to the Biden-/Harris Administration that NASA expand its traditional role to include a proactive R&D focus on mitigation and restoration of Arctic sea ice.*

Such an effort, if successful, could slow Arctic amplification, providing some stability to the Arctic region and thereby buy time for the international community to develop more fundamental global economic mitigation efforts and move rapidly from a fossil fuel economy to one based on renewable energy sources. While much effort has been focused on reducing and eventually eliminating the use of fossil fuels, an essential effort that must be seriously accelerated, existing atmospheric GHG will remain in the atmosphere for centuries<sup>35</sup>. Much more needs to be done to mitigate GW in the short term. Restoration of Arctic ice would complement and work in concert with reducing fossil fuel use along with other mitigation efforts to reduce atmospheric GHG. ***We need to use every safe and effective tool in the toolbox to win the climate crisis battle.***

### 4.0 PROGRAM DESCRIPTION - A NEW FEDERAL INITIATIVE: NATIONAL ARCTIC ICE RESTORATION INITIATIVE (NAIRI)

We propose the U.S. take a strong international leadership position in addressing Arctic climate issues and the possibility of ice restoration. We propose the U.S. establish a new research and development (R&D) initiative inspired by NOAA's National Hurricane Center (NHC) where both intramural and extramural scientists perform extensive modeling and monitoring research, and engineers develop mechanisms to deal with the destructive forces of hurricanes. This new R&D initiative, NAIRI, notionally led by NASA, would be focused on Arctic climate restoration. ***NAIRI would be a multiagency coordinated effort comprised of NASA, NSF, NOAA, DoE and DoD*** earth sciences and relevant allied programs associated with climate change and climate modeling. Annual funding for NAIRI would be at 2021 levels of appropriated budgets to the above Agencies ***augmented by an aggregated total of \$773M over 5 years.*** Augmented funds would be apportioned through NAIRI among participating Agencies and devoted to R&D into methodologies and demonstration projects designed to restore Arctic ice. NAIRI would also place significant emphasis and resources on updating and modernizing climate models incorporating a more accurate representation of the contribution of Arctic climate changes and Arctic ice representation in global warming models, thus improving prediction accuracy and capabilities. NAIRI would solicit and select concepts for research and projects from government, academic, non-profit and industry organizations in keeping with the standard practices currently used by NASA and other agencies.

Given the predicted enormous deleterious impacts of GW and associated climate changes, NAIRI would provide a coordinated and rigorous U.S. national multi-Agency R&D effort to understand the potential risks and benefits associated with proposed climate intervention approaches. It is important that the nation, and the world, have a variety of tools to use to avoid the disastrous impacts of GW on humans and all ecosystems. Only through R&D investments

can such understanding be gained. We further propose that NAIRI invest in experimental efforts designed to actively and safely geoengineer climate restoration through a variety of potential approaches. Approaches for restoration would be selected through solicitation. Initial feasibility of such approaches, mentioned here as proof of principle, was recently shown by a technology proposed by the Arctic Ice Project<sup>36,37</sup>. Initial laboratory and field studies along with preliminary modeling indicate that these technologies have the potential to sufficiently restore Arctic sea ice without the climate disruptions and termination effects associated with typical geoengineering approaches, most notably, stratospheric aerosol injection.

**4.1 Primary Program Goal:** Develop technology(s) to restore Arctic sea ice and increase sea ice albedo, thereby reducing energy absorption in the Arctic which significantly contributes to global warming produced by greenhouse gas emissions. Develop technology to Technology Readiness Level (TRL) 6-7 (Prototype demonstrated in applicable Arctic environment) by end of Year 5 and transfer technologies to a deployment organization for development to TRL 9.

**Secondary Goal:** Demonstrate feasibility of Arctic sea ice restoration in critical target areas overlying the Eastern Siberian Arctic Ocean shelf to effectively slow release of CO<sub>2</sub> and methane from thawing permafrost and associated release of methane from melting methyl hydrates from shallow offshore permafrost.

#### **4.2 Program Oversight**

We suggest a Program Office, notionally established within NASA and reporting to OSTP, would manage, integrate, and coordinate NAIRI projects and activities. Multi-Agency cooperation and communication would be essential to ensure seamless and synergistic efforts by all participating Agencies. An annual report from the NASA Administrator to OSTP, coordinated through all participating Federal Agencies and Departments, would provide data on progress of the initiative.

#### **4.3 Customers:**

- Participating agency management
- Office of Science and Technology Policy
- White House National Climate Advisor
- White House International Climate Envoy
- Domestic and International Policy Makers

## **5.0 AREAS OF RESEARCH**

Note that budgets and goals described below are notional and reflect *5-year totals* for each element. Specific budgets, goals, milestones, and requirements will, of course, be finalized by the President's Budget and Congressional appropriations.

### **5.1 Augment Current Studies of Arctic Processes**

Climate models continue to underestimate the rate of loss of ice and cryospheric radiative forcing in the Arctic as compared with observations, leading to doubts about how well these models can be trusted to predict future impacts. These underestimates are likely due to an incomplete understanding of cryospheric processes exacerbated by a lack of relevant observations.

Augmenting current programs aimed at better understanding Arctic processes is needed in three sub-elements listed below.

### **5.2 Augment Cryospheric Science (\$100M)**

All of the organizations which would participate in NAIRI already have programs that study Arctic processes. We recommend that these be augmented because of the important role of the Arctic in global (at least Northern Hemisphere) weather and climate change. The program

element would provide augmented funding for modeling, continued exploitation of current observations and further observations. This program element could be modeled after, or augment, the Cryospheric Science Solicitation of the RESEARCH OPPORTUNITIES IN SPACE AND EARTH SCIENCES – 2020 (ROSES-2020), NNH20ZDA001N-CRYO. The budget presented in the table below are scoped based on funding levels similar to the CRYO Announcement of Opportunity – each participating agency would have an augmented budget of \$2M per year per agency. Since changes in sea ice will likely impact ocean biology, air-sea exchanges, and ocean circulation this program element should provide funding for interdisciplinary research other related solicitations, for example Ocean Biology and Biogeochemistry, Physical Oceanography and Ocean Salinity.

**Goal:** Develop a better understanding of how the Arctic interacts with global weather through atmospheric and oceanic circulation patterns (teleconnections), the effects and consequences of Atlantification (intrusion of warmer Atlantic waters into the Arctic Ocean) regionally and globally, and the extent and potential impacts of carbon release due to thawing permafrost and melting of methane hydrate in the ocean.

### **5.3 Augment Field Measurements (\$125M)**

This program element would fund additional *in situ* and satellite observations needed to better understand cryospheric processes. Field measurements, especially in the harsh Arctic environment are more expensive. Thus, this program element is notionally scoped at \$5M per year per agency engaged in such studies.

**Goal:** To better understand cryospheric processes with additional *in situ* and satellite observations

### **5.4 Field Mission (\$152M)**

We propose the US lead an international follow-on mission to MOSAIC. NSF, NOAA and/or NASA would notionally be the lead organizations. The total 5-year cost of this field mission is estimated to be \$152M (U.S. portion) .

**Goal:** Obtain quantitative measurements and characterizations of important dynamic Arctic processes.

## **6.0 ACHIEVING ARCTIC ICE RESTORATION TECHNOLOGIES TO TRL 3 BY YEAR 5**

### **6.1 Solicitation, Feasibility and Concept Development to TRL 3 (\$45M)**

This program element may be modeled after NASA’s Innovative Advanced Concepts (NIAC). The NIAC Program “nurtures visionary ideas that could transform future NASA missions with the creation of breakthroughs.” This new element would be similar to these but focused on Arctic Ice Restoration. It is suggested that all participating agencies solicit proposals. This element is notionally scoped at \$9M for 5 years for each agency. Projects selected should include lab and small-scale deployments and plans for monitoring appropriate metrics during deployment.

Climate modeling, required to develop a scheme to determine the smallest, lowest cost, temporal and spatial application of the technique that yields the highest benefits, should be included.

**Goal 1:** Solicit Requests for Proposals for concepts for Arctic Ice Restoration that would restore Arctic sea ice and slow global warming in the Arctic regions and globally.

**Goal 2:** Conduct feasibility studies on the potential of selected concepts to restore Arctic sea ice.

**Goal 3:** Using models, determine if restoration of Arctic sea ice can effectively slow release of CO<sub>2</sub> and methane from thawing permafrost and release of methane from melting methyl hydrates from shallow offshore permafrost.

**Goal 4:** Mature concepts to TRL 3.

#### **6.2 Technology Maturation of Concept from TRL 3 to TRL 6/7 by year 5. (\$111M)**

This program element may be modeled after NASA's Game Changing Developments (GCD) Program. The Tipping Point solicitations of the GCD program that "seeks to identify and rapidly mature high-impact capabilities and technologies...". This element is focused on maturing technologies to restore Arctic ice: it is critical to give the scientific community, policy makers and the public confidence the concept(s) selected by NAIRI has the potential of meeting the program goal of developing technology(s) that can preserve and restore Arctic sea ice. Specific goals, requirements, and milestones would be determined by Agency program managers with the assistance of the research community which should devise an efficiency metric with which to judge techniques. It is expected that any proposed techniques would achieve at least TRL 6/7 by year 5. It is anticipated that later stages of deployment may involve public-private partnerships and Nation-state level participation. It is suggested that NASA lead this program element which is notionally scoped at \$111M for 5 years.

**Goal:** Mature current concept technology(s) from TRL 3 to TRL 6/7 by year 5.

**Goal:** Demonstrate that sufficient levels of ice growth can be developed to significantly reduce Summer Arctic Ocean energy absorption.

#### **6.3 Test Deployment of 2 concepts (\$90M)**

**Goal 1:** Down-select and fund 2 concepts for testing at meaningful scale under field conditions.

**Goal 2:** Develop a notional plan on how technology can be applied to scale in the field at TRL 9.

### **7.0 ASSESS THE IMPACTS OF PROPOSED ARCTIC MITIGATION CONCEPTS ON WEATHER, CLIMATE AND ECOSYSTEMS IN THE ARCTIC REGION, NORTHERN HEMISPHERE AND GLOBALLY (\$100M)**

Modeling impact studies will be conducted to determine how the planet will respond to proposed mitigation concepts. This program element is critical to give the scientific community, policy makers and the public confidence that the effects of these techniques are not likely to produce undesired or unintended consequences, are easily reversible, and have no termination effects. Studies funded by this program element would necessarily interact with other relevant programs elements. This program element could also provide supplemental funding for interdisciplinary research in other related solicitations. For example, Ocean Biology and Biogeochemistry, Physical Oceanography and Ocean Salinity. It could be modeled after Geoengineering Model Intercomparison Project (GeoMIP). Specific, goals, requirements, and milestones would be determined by the program manager with the assistance of the research community. Each participating agency would notionally have an augmented budget of \$4M per year per agency.

**Goal:** Determine how the planet will likely respond to Arctic sea ice mitigation concepts.

### **8.0 COST-BENEFIT AND RISK ANALYSES OF ARCTIC ICE RESTORATION TECHNOLOGY (\$50M)**

It will be critical to demonstrate to national stakeholders, international partners and the public that the regional and global damage resulting from further warming and Arctic sea ice loss far outweigh any short-term economic benefits from augmented commercial opportunities due to ice loss. For example, increased fossil fuel extraction in the region would both endanger local habitats and the livelihood of indigenous peoples, and also contribute to accelerating GHG emissions that the world should be aggressively seeking to limit. This program element would fund researchers to perform cost-benefit analyses that would include the effects on indigenous peoples and Arctic flora and fauna. Each participating agency would notionally have an augmented budget of \$2M per year per agency.

**Goal:** Conduct a cost-benefit risk analysis to assess the regional and global damages of further warming and sea ice loss relative to any short-term economic benefits of increased commercial activity in the Arctic.

## 9.0 NOTIONAL BUDGET AUGMENTATION (TOTAL FOR NAIRI)

Annual funding would notionally be at 2021 levels of appropriate elements of participating Agency budgets *augmented* by an aggregated total of \$773M over 5 years.

NAIRI BUDGET AUGMENTATIONS	Yr 1 Total	Yr 2 Total	Yr 3 Total	Yr 4 Total	Yr 5 Total	TOTAL Yrs 1-5
<b>Area of Research</b>						
Augment Current Studies of Arctic Processes						
Augment Cryospheric Science (all agencies)	20	20	20	20	20	100
Augment Field measurements (all agencies)	25	25	25	25	25	125
Field mission (NOAA)	2	10	50	50	40	152
<b>Achieving Arctic Ice Restoration Technologies To TRL 6/7 By Year 5</b>						
Solicitation, Feasibility and Concept Development to TRL 3 (all agencies)	5	10	15	15	0	45
Technology Maturation of Concept to TRL 6/7 (NASA)	6	15	30	30	30	111
Test Deployment of 2 Concepts (NASA)	0	0	30	30	30	90
<b>Assess impacts of Arctic Mitigation Concepts to Planet (all agencies)</b>	20	20	20	20	20	100
<b>Cost-benefit and Risk Analyses of Arctic Restoration Technology (all agencies)</b>	10	10	10	10	10	50
<b>Total across all agencies</b>	<b>88</b>	<b>110</b>	<b>170</b>	<b>160</b>	<b>145</b>	<b>773</b>

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