National Security and the Accelerating Risks of Climate Change

CNA Military Advisory Board

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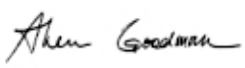

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LETTER OF TRANSMITTAL

Foreword

Projected climate change is a complex multi-decade challenge. Without action to build resilience, it will increase security risks over much of the planet. It will not only increase threats to developing nations in resource-challenged parts of the world, but it will also test the security of nations with robust capability, including significant elements of our National Power here at home. Even though we may not have 100 percent certainty as to the cause or even the exact magnitude of the impacts, the risks associated with projected climate change warrant taking action today to plan and prepare for changes in our communities, at home and abroad.

When it comes to thinking through long-term global challenges, none are more qualified than our most senior military leaders. Not only do they have decades of experience managing risk and responding to conflict on the battlefield, but they are also experts in geopolitical analysis and long-range strategic planning.

Military leaders typically look at challenges with imperfect or conflicting information. Despite not having 100 percent certainty, they weigh the consequences of various courses of action—including the consequences of no action—and make informed decisions based on their experience and risk forbearance.

It is through this analytical prism that 11 retired Generals and Admirals came together in 2007, under the moniker of CNA's Military Advisory Board, to examine the security implications of climate change. Their landmark report, *National Security and the Threat of Climate Change*, was the first time that such an elite body of military leaders expressed their concern over the security implications of climate change.

Now, seven years later, the Military Advisory Board has gathered again to re-examine the nexus of projected climate change and national security. This update reflects their decades of experience as risk managers and geopolitical security experts. With the foundation of CNA's established analytical prowess, the report deserves strong attention from not only the security community, but also from the entire government and the American public.

The update serves as a bipartisan call to action. It makes a compelling case that climate change is no longer a future threat—it is taking place now. It observes that climate change serves as a catalyst of conflict in vulnerable parts of the world, and that projected changes in global migration patterns will make the challenges even more severe. It identifies threats to elements of National Power here at home, particularly those associated with our infrastructure and our ability to maintain military readiness.

The update makes clear that actions to build resilience against the projected impacts of climate change are required today. We no longer have the option to wait and see. We applaud this group of American patriots for this important update. We commend its reading in full and its recommendations to the Administration, to Congress, and to the American people.

Michael Chertoff
Former Secretary of Homeland Security

Leon Panetta
Former Secretary of Defense

National Security and the Accelerating Risks of Climate Change

To the reader:

The nature and pace of observed climate changes—and an emerging scientific consensus on their projected consequences—pose severe risks for our national security. During our decades of experience in the U.S. military, we have addressed many national security challenges, from containment and deterrence of the Soviet nuclear threat during the Cold War to political extremism and transnational terrorism in recent years. The national security risks of projected climate change are as serious as any challenges we have faced.

Since we published our first report in 2007 on the national security implications of climate change, we have witnessed nearly a decade of scientific discoveries in environmental science, a burgeoning scholarly literature on global complex interdependence among nations, and a series of reactions (or in many cases, failures to react) to projected climate change. Hence, we were compelled to provide an update to our report. Over several months and meetings, we listened to scientists, security analysts, government officials, industry representatives, and the military. We viewed their information through the lens of our military experience as warfighters, planners, and leaders. Our discussions have been lively, informative, and very sobering.

At the end of the day, we validate the findings of our first report and find that in many cases the risks we identified are advancing noticeably faster than we anticipated. We also find the world becoming more complex in terms of the problems that plague its various regions. Yet thinking about how to manage the risks of projected climate change as just a regional problem or—worse yet—someone else's problem may limit the ability to fully understand their consequences and cascading effects. We see more clearly now that while projected climate change should serve as catalyst for change and cooperation, it can also be a catalyst for conflict.

We are dismayed that discussions of climate change have become so polarizing and have receded from the arena of informed public discourse and debate. Political posturing and budgetary woes cannot be allowed to inhibit discussion and debate over what so many believe to be a salient national security concern for our nation. Each citizen must ask what he or she can do individually to mitigate climate change, and collectively what his or her local, state, and national leaders are doing to ensure that the world is sustained for future generations. Are your communities, businesses, and governments investing in the necessary resilience measures to lower the risks associated with climate change? In a world of high complex interdependence, how will climate change in the far corners of the world affect your life and those of your children and grandchildren? If the answers to any of these questions make you worried or uncomfortable, we urge you to become involved. Time and tide wait for no one.

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Executive Summary

CNA's Military Advisory Board (MAB) first addressed the national security implications of climate change in our 2007 report—*National Security and the Threat of Climate Change*. We gather again as a group of 16 retired Generals and Admirals from the Army, Navy, Air Force, and Marine Corps to re-examine climate change in the context of a more informed, but more complex and integrated world, and to provide an update to our 2007 findings.

We are compelled to conduct this update now because of nearly seven years of developments in scientific climate projections; observed climate changes, particularly in the Arctic; the toll of observed extreme weather events both at home and abroad; and changes in the global security environment. Although we have seen some movement in mitigation and other areas where climate adaptation and resilience are starting to be included in planning documents, we gather again because of our growing concern over the lack of comprehensive action by both the United States and the international community to address the full spectrum of projected climate change issues.

The specific questions addressed in this update are:

1. Have new threats or opportunities associated with projected climate change or its effects emerged since our last report? What will be the impacts on our military?

2. The 2014 National Climate Assessment indicates that climate change, once considered an issue for a distant future, has moved firmly into the present. What additional responses should the national security community take to reduce the risks posed to our nation and to the elements of our National Power (Political, Military, Social, Infrastructure, and Information systems (PMESII))?

Major findings:

Actions by the United States and the international community have been insufficient to adapt to the challenges associated with projected climate change. Strengthening resilience to climate impacts already locked into the system is critical, but this will reduce long-term risk only if improvements in resilience are accompanied by actionable agreements on ways to stabilize climate change.

Scientists around the globe are increasing their confidence, narrowing their projections, and reaffirming the likely causes of climate change. As described in *Climate Change Impacts in the United States: The Third National Climate Assessment*: "Heat-trapping gases already in the atmosphere have committed us to a hotter future with more climate-related impacts over the next few decades. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, now and in the future."[1] Some in the political realm continue to debate the cause of a warming planet and demand more data. Yet MAB member General Gordon Sullivan, United States Army, Retired, has noted: "Speaking as a soldier, we never have 100 percent certainty. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield."

> **If you wait until you have 100 percent certainty, something bad is going to happen....**

Climate mitigation and adaptation efforts are emerging in various places around the world, but the extent of these efforts to mitigate and adapt to the projections are insufficient to avoid significant potential water, food, and energy insecurity; political instability; extreme weather events; and other manifestations of climate change. Coordinated, wide-scale, and well-executed actions to limit heat-trapping gases and increase resilience to help prevent and protect against the worst projected climate change impacts are required—now.

The potential security ramifications of global climate change should be serving as catalysts for cooperation and change. Instead, climate change impacts are already accelerating instability in vulnerable areas of the world and are serving as catalysts for conflict.

As we identified in our 2007 report—and as the Department of Defense's (DOD) 2014 Quadrennial Defense Review (QDR) echoed—the projected effects of climate change "... are threat multipliers that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions—conditions that can enable terrorist activity and other forms of violence."[2] We remain steadfast in our concern over the connection between climate change and national security.

... the projected impacts of climate change will be more than threat multipliers; they will serve as catalysts for instability and conflict.

In many areas, the projected impacts of climate change will be more than threat multipliers; they will serve as catalysts for instability and conflict. In Africa, Asia, and the Middle East, we are already seeing how the impacts of extreme weather, such as prolonged drought and flooding—and resulting food shortages, desertification, population dislocation and mass migration, and sea level rise—are posing security challenges to these regions' governments. We see these trends growing and accelerating. To protect our national security interests both at home and abroad, the United States must be more assertive and expand cooperation with our international allies to bring about change and build resilience. The rapidly changing Arctic region is a clear example where such international cooperation and change is imperative.

Rapid population growth, especially in coastal and urban areas, and complex changes in the global security environment have made understanding the strategic security risks of projected climate changes more challenging. When it comes to thinking about the impacts of climate change, we must guard against a failure of imagination.

The world has added more than half a billion people since we began the research for our 2007 report. During this period, hundreds of millions of people have settled in urban areas and coastal regions—areas that are at increased risk to climate change effects. At the same time, geopolitical power is becoming more dispersed. Nonstate actors, such as globalized financial institutions and corporations, and even Internet-empowered individuals—or the causes they represent—are having increasing impacts on the political landscape. The world has also become more politically complex and economically and financially interdependent. We believe it is no longer adequate to think of the projected climate impacts to any one region of the world in isolation. Climate change impacts transcend international borders and geographic areas of responsibility.

When it comes to thinking about how the world will respond to projected changes in the climate, we believe it is important to guard against a failure of imagination.

For example, in the summer of 2001, it was, at least partly, stovepipes in the intelligence community and a failure of imagination by security analysts that made it possible for terrorists to use box cutters to hijack commercial planes and turn them into weapons targeting the World Trade Center and the Pentagon. Regarding these threats, the 9/11 Commission found "The most important failure was one of imagination. We do not believe leaders understood the gravity of the threat. The … danger … was not a major topic for policy debate among the public, the media, or in the Congress…."[3] Failure to think about how climate change might impact globally interrelated systems could be stovepipe thinking, while failure to consider how climate change might impact all elements of U.S. National Power and security is a failure of imagination.

Climate change impacts transcend international borders and geographic areas of responsibility.

Accelerated melting of "old ice" in the Arctic is making the region more accessible to a wide variety of human activities, including shipping, resource extraction, fisheries, tourism, and other commerce. This activity level will accelerate in the coming decades. The United States and the international community are not prepared for the pace of change in the Arctic

In 2012, the level of ice coverage in the Arctic was lower than the historic average by more than one million square miles. While annual figures vary, the overall trend is clearly toward less ice coverage. The Arctic is rich in resources, and less ice will mean that valuable resources and shorter transit routes will be increasingly accessible. Nations, corporations, and even individuals will be anxious to exploit the opening Arctic region, even if they have to accept higher levels of risk than in other areas of the world. While the United States and the international community prepare for more Arctic activities in the future, the increased activity today brings high levels of risk to that fragile area. The U.S. military's current construct of dividing the Arctic area of responsibility (AOR) between two Combatant Commands (CCMDs) under DOD's Unified Command Plan likely will slow the Defense Department's ability to generate requirements and respond. Although the United States is a member of the Arctic Council—an intergovernmental consultative group—its refusal to sign the UN Convention on the Law of the Sea will make U.S. participation in the resolution of international disputes in the Arctic more challenging.

As the world's population and living standards continue to grow, the projected climate impacts on the nexus of water, food, and energy security become more profound. Fresh water, food, and energy are inextricably linked, and the choices made over how these finite resources will be produced, distributed, and used will have increasing security implications.

From today's baseline of 7.1 billion people, the world's population is expected to grow to more than 8 billion by 2025. The U.S. National Intelligence Council assesses that by 2030, population growth and a burgeoning global middle class will result in a worldwide demand for 35 percent more food and 50 percent more energy.[4] Rising temperatures across the middle latitudes of the world will increase the demand for water and energy. These growing demands will stress resources, constrain development, and increase competition among agriculture, energy production, and human sustenance. In light of projected climate change, stresses on the water-food-energy nexus are a mounting security concern across a growing segment of the world.

... stresses on the water-food-energy nexus are a mounting security concern across a growing segment of the world.

Projected climate change impacts inside the borders of the United States will challenge key elements of our National Power and encumber our homeland security. Of particular concern are climate impacts to our military, infrastructure, economic, and social support systems

The projected impacts of climate change—heat waves, intense rainfall, floods and droughts, rising sea levels, more acidic oceans, and melting glaciers and arctic sea ice—not only affect local communities but also, in the aggregate, challenge key elements of our National Power.* Key elements of National Power include political, military, economic, social, infrastructure, and information systems.

... impacts of climate change will strain our military forces in the coming decades.

Military. The projected impacts of climate change could be detrimental to military readiness, strain base resilience both at home and abroad, and may limit our ability to respond to future demands.

* In a security context, National Power is the ability to remain sovereign, protect national assets, and influence the behavior of others toward a desired outcome. Although the United States has embraced a more complex construct of National Power, a series of formal policy documents have introduced contrasting models of power, indicating that National Power has multiple and overlapping sources. In one of its simplest paradigms, National Power is modeled in terms of the ability to exert pressure through diplomatic, informational, military, and economic means (DIME). National Power can also be assessed by degradations to a nation's political, military, economic, social, infrastructure, and information systems (PMESII). We are concerned about how projected climate change could degrade our National Power/PMESII.

The projected impacts of climate change will strain our military forces in the coming decades. More forces will be called on to respond in the wake of extreme weather events at home and abroad, limiting their ability to respond to other contingencies. Projected climate change will make training more difficult, while at the same time, putting at greater risk critical military logistics, transportation systems, and infrastructure, both on and off base.

Infrastructure. The impacts of projected climate change can be detrimental to the physical components of our national critical infrastructure, while also limiting their capacities.

The nation depends on critical infrastructure for economic prosperity, safety, and the essentials of everyday life. Projected climate change will impact all 16 critical infrastructure sectors identified in Homeland Security planning directives. We are already seeing how extreme heat is damaging the national transportation infrastructure such as roads, rail lines, and airport runways. We also note that much of the nation's energy infrastructure—including oil and gas refineries, storage tanks, power plants, and electricity transmission lines—are located in coastal floodplains, where they are increasingly threatened by more intense storms, extreme flooding, and rising sea levels. Projected increased temperatures and drought across much of the nation will strain energy systems with more demand for cooling, possibly dislocate and reduce food production, and result in water scarcity. Since much of the critical infrastructure is owned or operated by the private sector, government solutions alone will not address the full range of climate-related issues.

Economic. The projected impacts of climate change will threaten major sections of the U.S. economy.

According to the 2014 National Climate Assessment, "The observed warming and other climatic changes are triggering wide-ranging impacts in every region of our country and throughout our economy…."[5] Most of the U.S. economic sectors, including international trade, will be affected by projected climate change.

Social. The projected impacts of climate change will affect major sections of our society and stress social support systems such as first responders.

As coastal regions become increasingly populated and developed, more frequent or severe storms will threaten vulnerable populations in these areas and increase the requirements for emergency responders in terms of frequency and severity of storms. Simultaneous or widespread extreme weather events and/or wildfires, accompanied by mass evacuations, and degraded critical infrastructure could outstrip local and federal government resources, and require the increased use of military and private sector support.

Recommendations:

1. **To lower our national security risks, the United States should take a global leadership role in preparing for the projected impacts of climate change.**

   This leadership role includes working with other nations, as well as with emerging nongovernmental and intergovernmental stakeholders—such as the Group of Seven (G-7), the World Trade Organization (WTO), private foundations, and so forth—to build resilience for the projected impacts of climate change. At the same time, the U.S. should lead global efforts to develop sustainable and more efficient energy solutions to help slow climate change.

2. **Supported by National Intelligence Estimates, the U.S. military's Combatant Commanders (CCMDs) should factor in the impacts of projected climate change across their full spectrum of planning and operations.**

   With partner nations, CCMDs should focus on building capacity and sustained resilience. Across their areas of responsibility, they should work with nations and emerging nongovernmental and intergovernmental stakeholders to lower risk in those areas where the impacts of climate change likely will serve as a catalyst for conflict.

3. **The United States should accelerate and consolidate its efforts to prepare for increased access and military operations in the Arctic.**

   DOD and other U.S. government agencies should build on and accelerate plans recently put forward in Arctic strategic planning documents. The Arctic is already becoming viable for commercial shipping and increased resource exploitation. The time to act is now. To expedite crisis response and requirements generation, the Arctic region should be assigned to one CCMD. To provide the United States with better standing in resolving future disputes in the Arctic, the U.S. should become a signatory to the UN Convention on the Law of the Sea (UNCLOS).

4. **Climate adaptation planning should consider the water-food-energy nexus to ensure comprehensive decision making.**

   Rapidly growing population and urbanization, combined with changes in weather patterns, will stress resource production and distribution, particularly water, food, and energy. These vital resources are linked, and adaptation planning must earnestly consider their interrelationships.

5. **The projected impacts of climate change should be integrated fully into the National Infrastructure Protection Plan and the Strategic National Risk Assessment.**

   As military leaders, we know that we cannot wait for certainty. The failure to include a range of probabilities because it is not precise is unacceptable. The Strategic National Risk Assessment must include projected impacts of climate change over the coming decades so that resilience needs and requirements associated with these projections can be better defined in the National Infrastructure Protection Plan.

6. **In addition to DOD's conducting comprehensive assessments of the impacts of climate change on mission and operational resilience, the Department should develop, fund, and implement plans to adapt, including developing metrics for measuring climate impacts and resilience. The Department should place a greater emphasis on the projected impacts of climate change on both DOD facilities and associated community infrastructures.**

   This recommendation includes decisions to be made through any future processes, including base realignment and closure (BRAC), as well as expanding climate projections in planning and design factors for new bases, training facilities, or other infrastructure. In new or even existing bases, DOD should explore innovative solutions such as public-private partnerships to build climate change–resilient infrastructure, both on and off base. Climate change impacts should be considered in all vulnerability assessments, now and going forward.

Voices of Experience

REAR ADMIRAL DAVID W. TITLEY, USN (Ret.)
Former Oceanographer and Navigator of the Navy

On Climate Science

As the former Oceanographer and Navigator of the Navy, Rear Admiral (ret.) David W. Titley is all too familiar with computer modeling and other scientific ways of studying climate change. But he says its impact was illustrated most dramatically to him during an encounter with an Inuit Eskimo aboard a U.S. Coast Guard ship.

The two men were standing on the ship's bridge in the summer of 2010 as it sailed about 100 miles north of Barrow, Alaska. When he noticed a gauge showing the water temperature was just above 40 degrees, Titley asked his companion if he had ever seen the water that warm, or if his tribe's oral histories ever mentioned such warmth. In both cases, the reply was no. "That really brought this home—here we're talking to the Inuit, the people who have lived here for thousands of years," Titley recalled. "They have forgotten more about how to live in the Arctic than most Western men will ever know … and they had never seen this. That, to me, was pretty profound."

Titley and other scientists say overall ocean temperatures have responded more slowly than Earth's land environment to climate change. But they have warmed enough from the oceans' surfaces to a depth of about 2,000 feet to have a substantial impact on corals and marine life. In addition, warmer surface water dissipates more readily into vapor, making it easier for small ocean storms to become larger and more intense. The link between warmer oceans from climate change and major weather events such as hurricanes isn't conclusive. But Titley says science increasingly is making such connections clearer.

"What we've seen for decades is refinement [in the science]," he said. "It's like when you wake up in the morning, your eyes are maybe 20/1000, and then when you try to open them, it's 20/400. So let's say the science is maybe 20/50 for what we understand. We still don't see everything perfectly, but we have sharper resolution."

Titley speaks regularly on climate change to audiences around the country, including testifying at a 2013 hearing of the U.S. House of Representatives Science, Space, and Technology Committee's Subcommittee on the Environment. After his 32-year Navy career ended, he served as Deputy Undersecretary of Commerce for Operations, the chief operating officer position at the National Oceanic and Atmospheric Administration. He is now a meteorology professor at Penn State University and director of its Center for Solutions to Weather and Climate Risk.

In his presentations, Titley emphasizes both the rapidity of change and the need to manage risk in a civilization that has become globalized and interdependent. "Now as we start accelerating the changes in climate, are we going to manage that adaptation quicker than the climate changes, or vice versa?" he asked. "If we can do it, it'll be a bumpy ride, but we'll all still be in our seatbelts and the car will be okay, if we can hang on.

"We know that when things go really bad, that's when the U.S. military is called in," he added. "That's why I see climate change as a national security issue."

Another thing the public should understand, he said, is that the scientific foundation for understanding climate change isn't new—it was laid more than a century ago.

It came from the work of French mathematician Joseph Fourier, who in the 1820s studied the factors influencing temperature; Irish physicist John Tyndall, who demonstrated four decades later that gases such as carbon dioxide could trap heat in the atmosphere; and Swedish scientist Svante Arrhenius, who subsequently determined that an increase in the amount of carbon dioxide would result in a certain amount of warming.

"I tell people, this is cutting-edge 19th century science that we're now refining," Titley said.

I. Why the MAB Is Issuing This Report Now

- **We are already seeing the impacts of climate change that were predicted at the time of our first report. In some cases, the impacts are developing faster than we predicted. Action is needed now.**
- **Projected climate change scenarios could become "catalysts for conflict" that could worsen problems both at home and abroad.**
- **We are increasingly concerned over the lack of comprehensive action by the international community to address projected climate change issues. The United States has an obligation to take a leadership role.**

In 2006, CNA convened a Military Advisory Board (MAB) of retired three-star and four-star Admirals and Generals to assess the actual and projected impacts of global climate change on key matters of national security. Our 2007 report, *National Security and the Threat of Climate Change*, identified climate change as a "threat multiplier" for instability in some of the most volatile regions of the world and laid the groundwork for mounting responses to address these threats. This military perspective is now reflected across the security community, including DOD's 2014 Quadrennial Defense Review (QDR), in which the effects of climate change are identified as "threat multipliers that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions—conditions that can enable terrorist activity and other forms of violence."[6]

Seven years have passed since our initial assessment. During this period, we have witnessed more frequent and/or intense weather events, including heat waves, sustained heavy downpours, floods in some regions, and droughts in others areas. Nine of the ten costliest storms to hit the United States have occurred in the past 10 years, including Hurricane Katrina and Superstorm Sandy. Globally, we have seen recent prolonged drought act as a factor driving both spikes in food prices and mass displacement of populations, each contributing to instability and eventual conflict. We have observed unprecedented wildfires threaten homes, habitats, and food supplies, not only across the United States, but also across Australia, Europe, Central Russia, and China. We have seen entire low-lying island nations begin to plan for complete evacuation to escape rising sea levels. We have seen record melting of the Arctic ice and more than a hundredfold increase in operations in that fragile area.

In addition to observed changes in weather patterns, we note that the scientific community continues to coalesce around the projected impacts of climate change. According to the 2014 U.S. National Climate Assessment: "More than 97 percent of scientists in this field agree that the world is unequivocally warming and that human activity is the primary cause of the warming experienced over the past 50 years."[7]

Even very low probability events with devastating consequences must be considered....

We recognize that skepticism is important in the scientific process, especially in the continual refinement of theories, and that healthy debate in the area of climate change can serve to advance science, but falling short of 100 percent agreement is not a justifiable reason for inaction. As noted by MAB member Admiral Frank "Skip" Bowman, United States Navy, Retired:

> Managing risk is seldom about dealing with absolute certainties but, rather, involves careful analysis of the probability of an event and the resultant consequences of that event occurring. Even very low probability events with devastating consequences must be considered and mitigation/adaptation schemes developed and employed. We operate our nuclear submarine fleet in this

fashion. Some may argue that this continuing process results in overdesign and overcautiousness. Maybe so, but our U.S. submarine safety record testifies to the wisdom of this approach. That's where we should be with climate change knowns and unknowns.

As we witness the climate around us changing, we also observe a growing segment of the population becoming increasingly at risk to the effects of climate changes. Since 2006, more than half a billion people have been added to the world's population. Most of that population growth has been in areas already suffering water and food resource challenges. Across the globe, we have also seen a tremendous shift of population to the coasts and urban areas. Half of the world's population now lives in cities, and according to the United Nations, about one billion are urban slum dwellers.

As we witness the climate around us changing, we also observe a growing segment of the population becoming increasingly at risk....

While cities can hold the promise of providing more efficient services, the reality is that urban living promotes more resource-intensive lifestyles and concentrates consumption and waste production. In light of these shifting demographics, we believe that the projected impacts of climate change will stress already-limited resources and negatively impact governments' abilities to provide necessary human support systems. Populations will likely become disenfranchised and even more vulnerable to extremists and revolutionary influences. In these areas, climate change will not only multiply threats, but will serve as a potential catalyst for conflict.

DOD's 2014 QDR observes that "average global temperatures are increasing, and severe weather patterns are accelerating. These changes, coupled with other global dynamics, including growing, urbanizing, more affluent populations … will devastate homes, land, and infrastructure."

This strategic defense planning document furthe warns, "The impacts of climate change may increase the frequency, scale, and complexity of future [DOD] missions."[9] At the same time, it describes the need for the United States to make "tough choices … in a period of fiscal austerity to maintain the world's finest fighting forces. These include reducing force structure in order to protect and expand critical capabilities, modernizing the forces, and investing in readiness."[10] As a result, we are issuing this update to revisit the nexus of climate change and national security, and to highlight the need for these "tough choices" to consider fully the projected impacts of climate change.

Recognition of the Risks

It is the MAB's collective experience that the risks associated with climate change, as identified in its 2007 report, are comprehensive and accelerating. The observed rapidity of climate change has resulted in effects that are becoming more than just "threat multipliers." We believe that without action to build resilience in the most vulnerable parts of the world, the projected impacts of climate change will likely serve as catalysts for conflict. On the positive side, recognition of the risk can lead to increased collaboration; thus we see climate change also serving as a catalyst for cooperation and change.

... climate change will not only multiply threats, but will serve as a potential catalyst for conflict.

Within the past seven years, the world has moved toward a greater understanding of the threats posed by projected climate change and is now moving to find collaborative solutions. Most countries now identify climate change as a national security threat, either through national planning documents or in the pronouncements of senior political leaders. The projected impacts of climate change are also now included in the U.S. National Security Strategy and Defense Strategic Guidance, including National Intelligence Estimates. All U.S. federal agencies are now directed to "evaluate the most significant climate change–related risks to, and vulnerabilities in, agency operations and missions in both the short and long term, and outline actions that agencies will take to manage these risks and vulnerabilities."[11]

Better Recognition and Better Data, but Wild Cards Remain

Just as nations are beginning to recognize the consequences of climate change and realizing the implications of the worst climate change projections, we are seeing the scientific community coalesce and refine their predictions. Improved models, targeted satellite monitoring and measurements, and better data collection systems all are contributing to increased confidence levels of projected changes, and we are increasingly able to base assessments on measured and measurable data. While some disagreement about the degree—and even the occurrence—of changes to our climate continues (particularly in U.S. political forums), the potential consequences of projected climate-change events are so significant that the prudent course is to assess how these predictions may affect our national security, and to take action now.

... the risks posed by predicted climate change ... represent even graver potential than they did seven years ago and require action today to reduce risk tomorrow.

As we indicated in our earlier report, a military leader's perspective of risk often differs from those of scientists, policymakers, or the media. Rather than assessing a range of estimates as proof of disagreement that can be used to justify inaction, military leaders view such evidence through the lens of varying degrees of risk the estimates could represent. As military leaders, we evaluate the probability and possible consequences of events in determining overall risk. Even for those outcomes or projected scenarios that have low probabilities of occurrence, if the consequence is high enough, the resulting risk demands action. Today, the risks posed by predicted climate change, in our view, represent even graver potential than they did seven years ago and require action today to reduce risk tomorrow.

We acknowledge and are concerned about the measured effect of rising global temperatures and the implications they have on projected climate change around the world. Other events that are being measured with greater accuracy since 2007 include:

- **A longer fire season.** Scientists say evidence suggests more fire seasons that are longer and stronger across all regions of the U.S. in the next 30 to 50 years. High fire years, such as the 2012 season—the third worst in U.S. history—would likely occur two to four times per decade by mid-century, instead of once per decade under historic climate conditions.[12] In 2013, Australia had its worst wildfires in history.
- **An acceleration of sea-level rise.** According to the 2014 National Climate Assessment, over the past century average sea levels have risen eight inches, with most of that rise occurring since 1980. The one-hundred-year storm surge, such as that associated with Superstorm Sandy, can now be expected every 10–20 years.[13] The Intergovernmental Panel on Climate Change (IPCC) now expects area-level rise of between 17 and 29 inches by the end of the century—a 70 percent to 190 percent increase over the estimation in the panel's 2007 report.[14]
- **The continued collapse in both the density and volume of sea ice in the Arctic Ocean.** The 2014 National Climate Assessment indicates that the models most accurately projecting historical sea ice trends currently suggest an essentially ice-free Arctic summer occurring for the first time, between 2021 and 2043.[15]
- **The movement of plant-, animal-, and vector-borne diseases toward higher elevations and latitudes.** The National Climate Assessment notes that normally stationary flora and fauna are moving to higher latitudes and/or to higher elevations at a rate of 10.5 miles and 36 feet per decade.[16] The unfortunate consequence is a greater risk to crops from pests and invasive species and greater threats to humans from diseases carried by mosquitos, such as West Nile virus and dengue fever.
- **Precipitation becoming more irregular and intense.** The scientific community projects that climate change will increase the frequency and intensity of heavy rainstorms (or snowstorms) in some regions of the world, and that extreme precipitation events very likely will become even more intense and more frequent by the end of the century as global surface temperatures continue to increase.
- **Drought and increased stress to fresh water systems**. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability,* the Intergovernmental Panel on

Climate Change found that in dry regions, drought frequency likely will increase by the end of the century. This trend is projected to reduce renewable surface water and groundwater resources significantly and intensify competition for water. In addition, climate change is projected to reduce freshwater quality and pose risks to drinking water quality due to interacting factors such as increased sediment, nutrient, and pollutant loads from heavy rainfall; increased concentration of pollutants during droughts; and disruption of treatment facilities during floods.[17]

Contributing to the ongoing climate change debate are natural variations in weather patterns. Although pundits may try, no individual weather event or weather season can be attributed decisively to climate change. *Weather* is what occurs day-to-day; *climate* describes weather patterns over decades. However, rather than wondering if any specific events are "caused" by climate change, MAB member Rear Admiral David Titley, United States Navy, Retired, suggests an alternative way of thinking about recent weather phenomena: "It is more useful to think of climate as the deck of cards from which our daily weather events are dealt. As the climate changes, so does our deck of cards. For every degree of warming, we add an extra ace into the deck. Over time, unusual hands such as a full house with aces high become more plausible and more common."

Even though the scientific community is coalescing around standard climate change predictions, it is important to keep in mind that some "wild cards" remain. One of the most significant is the West Antarctic Ice Sheet: If it melts or even calves at an accelerated rate, it has the potential to raise sea levels by several meters within a few decades. Scientific data indicate that the ice sheet is losing more ice than is being replaced, yet scientists remain uncertain about its future.

A second "wild card" is the ability of the ocean to adapt to increased acidification. The oceans are the world's largest carbon "sinks," as they absorb about one-quarter of the carbon dioxide emitted into the atmosphere each year. The more carbon dioxide that is absorbed, the more acidic the seawater becomes. This ocean acidification reduces the capacity of marine organisms with shells or skeletons made of calcium carbonate (such as corals, krill, shelled mollusks, and shellfish) to survive, grow, and reproduce. This phenomenon affects the entire aquatic food chain. Disruption of the food supplies from the ocean could cause food shortages around the globe, with considerable security implications. The ability of the ocean organisms to adapt to this unprecedented rate of acidification is unclear.

II. Evolving International Implications of Climate Change

- **Across the world, we are seeing interrelated and cascading effects from climate change events.**
- **Complex changes in the global security environment, including urbanization, population growth, and the movement of people to coastal areas, have cast climate change projections as even more of a strategic security risk.**
- **Stress to the water-food-energy nexus is a growing security concern.**
- **The United States must strengthen its international alliances and partnerships in preparing for the impacts of predicted climate change.**

Geopolitical stability is a primary goal for those concerned with national security. Maintaining stability within and among nations typically is a means of avoiding large-scale conflicts. Conversely, instability in key areas can threaten our security. Much of the emphasis on national security since the end of the Cold War has been focused on protecting stability where it exists and trying to foster it where it does not.

Our fundamental findings in the first report remain valid: Climate change can act as a threat multiplier for instability in some of the most volatile regions of the world, and it presents significant national security challenges for the United States. The report noted that climate change—much like terrorism or cyber-attacks—falls into the genre of threats that are unconstrained by national or international borders. The 2007 report identified several destabilizing impacts that endure:

- **Reduced access to fresh water:** Changes in rainfall, snowfall, snowmelt, and glacial melt have significant effects on freshwater supplies.
- **Impaired food production:** Increased desertification, rising sea levels infiltrating agricultural land, the salinization of aquifers, and drought also will lead to changes in food production. Access to vital resources—primarily food and water—has been the cause of many conflicts.
- **Health catastrophes:** A major concern remains the potential for significant spreading of the conditions for vector-borne diseases, such as dengue fever and malaria, and heat-related deaths in vulnerable populations.
- **Land loss and flooding leading to population displacement:** About two-thirds of the world's population lives near coastlines. Most of the economically important major rivers and river deltas in the world—the Niger, the Mekong, the Yangtze, the Ganges, the Nile, and the Mississippi—are densely populated along their banks.

A Changing World

Of special concern to the MAB is that we are seeing the accelerated effects of climate change at a time when global security conditions are also changing rapidly. It is important to emphasize that not only is there now a more complex global security environment, but also that the world is increasingly interconnected and interdependent in manufacturing, and in food and energy production.

... we are seeing the accelerated effects of climate change at a time when global security conditions are also changing rapidly.

Our first report did not address these global interrelationships in depth, but subsequently we have seen interrelated and cascading weather-related effects across the world's regions. U.S. leaders have highlighted the national security implications of climate change in a more complex-interdependent world:

- George W. Bush said in 2001: "The issue of climate change respects no border. Its effects cannot be reined in by an army nor advanced by any ideology.

Voices of Experience

GENERAL CHARLES F. WALD, USAF (Ret.)
Former Deputy Commander, U.S. European Command

LT. GEN. KEITH J. STALDER, USMC (Ret.)
Former Commander, U.S. Marine Corps Forces Pacific

REAR ADM. NEIL MORISETTI, BRITISH ROYAL NAVY (Ret.)
UK Foreign Commonwealth, Special Representative for Climate Change

On Changing Geopolitics

At the outset of General Wald's service in Europe in 2003, he was surprised to find that some strategies had become outdated. "We found out that we had not updated the war plan to make it current since 1989, when we had a current plan based on the [Cold War–era] Warsaw Pact," he recalled. "The reason was, we didn't know what the world was going to be."

Along with General Stalder and Admiral Morisetti, General Wald believes that such planning lapses no longer can be tolerated as the world has evolved even further over the last decade—especially when it comes to climate change. That's because it's an issue that, as General Wald noted, "has no concept of what a border is," and because problems in one nation can have severe implications for numerous others.

Rear Admiral Morisetti, who served as the British Foreign Ministry's top climate official, pointed to the international effects of climate change on coastal areas—where offshore oil-drilling rigs are located—that are expected to bear the brunt of increased severe weather, flooding, and other problems.

"That's an economic shock; it affects our competitiveness and growth," he said. "There's also uncertainty about raw materials, disruption of supply chains. These countries are often new markets as well—both the United States and the UK look to those emerging markets for growth. So it's tempting to see it as a local problem, but it's a global one."

Because of the interconnectedness of the threat, however, climate change affords the United States the opportunity to engage with other nations. As the Obama administration looks to rebalance to the Asia-Pacific region, General Stalder said, China and Japan are good potential candidates for collaboration.

"One of the things missing in the Western Pacific is this business of multilateralism," he said. "The region is very much a bilateral region, mostly bilateral as in the U.S. and another nation. There's a lot better value in true multilateralism, multinational cooperation. This kind of thing could be a rallying point. The military part is the easiest part of it.... We know how to work with other militaries, and they know how to work with us."

Addressing climate change is expensive, so those costs should be shared as much as possible, General Wald agreed. "It's also massive and unpredictable as to where it's going to be," he said. "You'd like to interface with other governments to arrive at an understanding of interoperability issues. When people train together, they become more accepting of what the perceived threat is."

Admiral Morisetti emphasized that developed nations can be of service to developing ones, particularly when it comes to helping them develop their first-responder capabilities. Otherwise, he warned, "We are going to find our countries having to deploy our military more frequently in this role, and it may not always be a benign environment. That it won't be a benign environment will be the exception rather than the norm, but I don't think you can rule that out."

General Stalder said he'd like to see a new multilateral arrangement emerge to address climate change. "From my perspective," he said, "the opportunity that it creates is an operating construct among the coalition of the willing to respond to things in a more cohesive way than is done right now, including a sort of standing command arrangement or coordination arrangement where countries could contribute to that and offer relief more quickly."

Climate change, with its potential to impact every corner of the world, is an issue that must be addressed by the world."[18]

- Thomas Fingar, chairman of the National Intelligence Council under President Bush, testified in 2008: "Global climate change will have wide-ranging implications for U.S. national security interests over the next 20 years."[19]
- In 2013, Navy Admiral Samuel Locklear, Commander of U.S. Pacific Command, identified climate change as the pacific region's biggest long-term security threat. Climate change "is probably the most likely thing that is going to happen ... that will cripple the security environment, probably more likely than the other scenarios we all often talk about."[20]
- Secretary of Defense Chuck Hagel, in a 2013 address at the Halifax International Security Forum, said that climate change "... can add to the challenges of global instability, hunger, poverty, and conflict. Food and water shortages, pandemic disease, disputes over refugees and resources, more severe natural disasters—all place additional burdens on economies, societies, and institutions around the world."[21]

The 2007 report was comprehensive in assessing the global threats and highlighting the potential for the impacts of climate change to contribute to failed states that could lead to the strengthening of non-state actors. However, the MAB believes it is important to emphasize the emergence of a new, more complex global security environment. We are seeing the steady erosion of the nation-state as the primary international security entity. Of increasing concern are empowered nonstate actors such as terrorists, extremist groups and gangs, individual or state-sponsored hackers who can launch crippling cyber-attacks, as well as large illegitimate financial entities and extremist political movements, powered by global communications networks, that wield increasing influence and authority. These nonstate actors represent "enemies without borders."

A recent example of one such nonstate actor enabled by the impacts of climate change is Al Qaeda in the Islamic Maghreb (AQIM) in Mali. The crises in and around the landlocked West African nation in 2012–2014 were shaped by an intersection of three salient trends: desertification and food insecurity exacerbated by climate change; an ongoing rebellion by Tuareg nomadic herdsmen in northern Mali; and weak government institutions that could not address the marginalization of the Tuareg and their increasing clashes with sedentary agriculturalist tribes in the southern and central areas of the country.[22] Overwhelmed by these challenges, the fragile government was overthrown by a coup in March 2012. Following the coup, the Malian political system was unable to maintain influence in northern Mali; AQIM and other groups moved in and took control.[23] As we write this report, in spite of the support of French and African Union troops, the Malian government has not been able to regain control of northern Mali from these forces, and the conflict continues.

While climate change alone did not cause the conflict, it certainly added environmental stressors to the once-coexistent relationship between the Arab Tuareg and non-Arab Muslim ethnic groups in central and southern Mali. In fact, the recent Malian conflict fits a pattern of other such conflicts in Africa's Sahel region, including Darfur, South Sudan, Niger, and Nigeria. Climate change—particularly drought and desertification—have impacted the region for hundreds of years; yet the region's environmental stressors have now become a threat multiplier across Sub-Saharan Africa, and have contributed to conflict dynamics in countries that have never enjoyed popular internal sovereignty in the postcolonial era or robust institutions to settle conflicts over vital resources. Add to this the involvement of transnational terrorist groups and militias such as AQIM and the *janjaweed* (in Mali and Darfur, respectively) and these conflicts become more complex, transforming resource competition into ethnopolitical conflict.

In northern Africa a growing body of academic research indicates that although environmental stressors similarly did not "cause" the Arab uprisings of 2011, the impacts of climate change may also have served as catalysts for these conflicts.[24] For example, the research notes that drought conditions in Russia and China, and subsequent global wheat shortages, contributed to higher food prices in Northern Africa and may have helped catalyze and sustain the Tunisian and Egyptian uprisings in 2011. Syria's ongoing conflict was preceded by five years of devastating droughts, coupled with unresponsive state institutions, and overgrazing that decimated livestock,

devastated 75 percent of crops in some regions, and forced millions to migrate to urban areas. In both rural areas affected by water and land insecurity, and urban areas burdened by inadequate support systems, antigovernment forces were emboldened. It is the MAB's hope that a better understanding of these types of cascading climate-related impacts, along with proactive efforts, can help avoid similar future conflicts.

Risk to Emerging Economies and Markets

Emerging economies are working to understand the threats they face from climate change projections, but they are far from prepared to deal with the challenges. Many of the emerging economies—from Ethiopia to Panama to Timor-Leste—lack resilience against exposure to sea level rise, warming temperatures, flooding, droughts, and other climate change effects—which threaten not only their fragile internal stability, but also the effectiveness and value of their part of the supply chains on which the global economy relies. Climate change impacts both emerging economies as suppliers of raw materials, and emerging markets as buyers and intermediate suppliers of global goods and services.

In short, the volatile mixture of population growth, instability due to the growing influence of nonstate actors, and the inevitable competition over scarce resources will be multiplied and exaggerated by climate change. MAB member Rear Admiral Titley warned of the potential for the military to be drawn into future situations: "We are going to look back and say that if climate change was just humanitarian assistance and disaster relief for the military, we had it good.... I am afraid that we will soon start getting into varsity-level instability."

All of these developments dramatically underscore the need to strengthen U.S. alliances and strategic partnerships with other nations, to build capacity in those nations, and improve coordination and response operations, while working on interoperability and standardization. This applies to equipment and procedures, as well as command-and-control capabilities during crises.

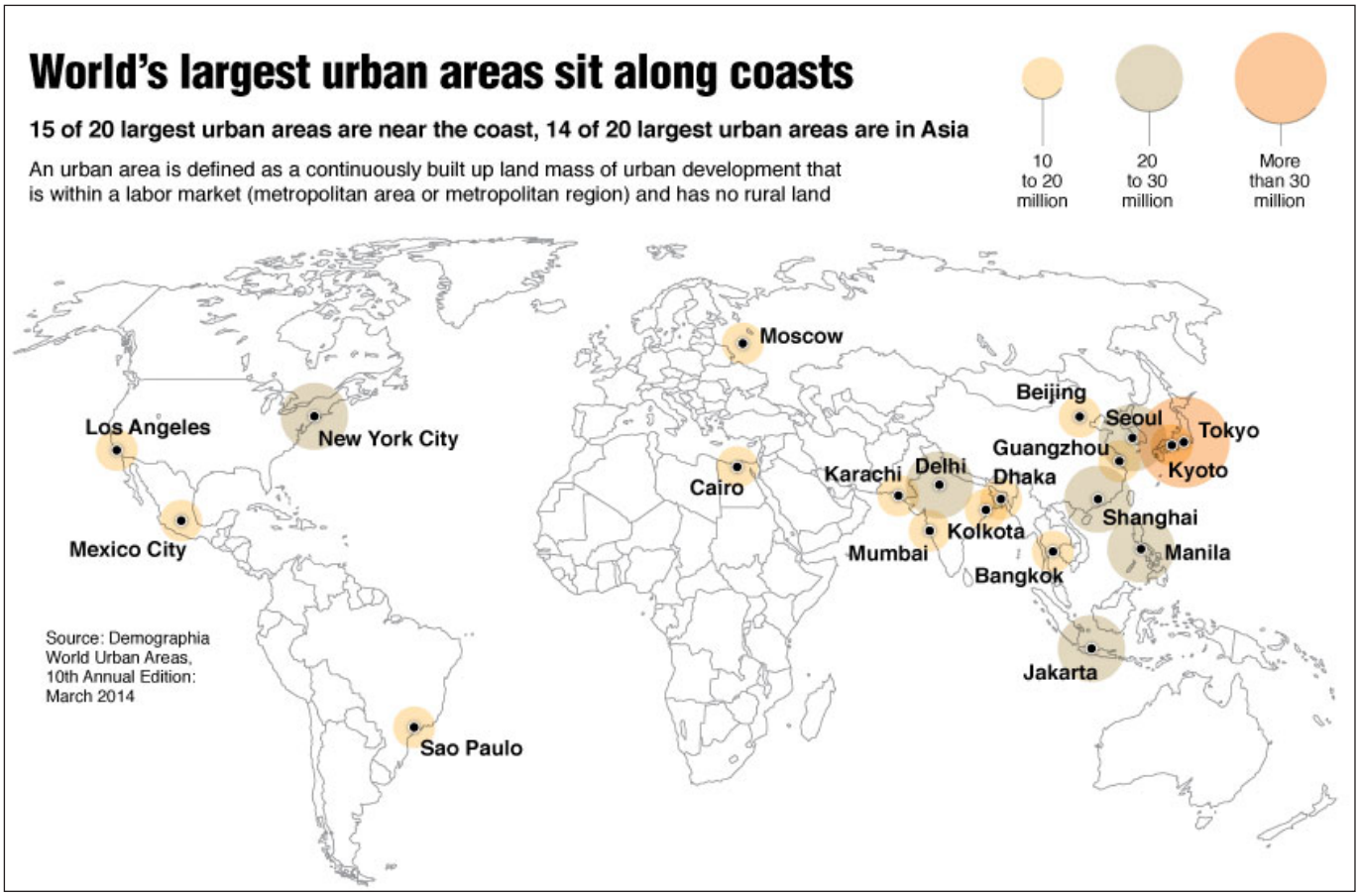
Asia and the Changing U.S. Security Posture

As described in DOD's 2014 Quadrennial Defense Review, the United States is shifting the strategic focus of its foreign policy through a "rebalancing of force structure to the Asia-Pacific region to preserve peace and stability in the region."[25]

As the United States seeks to exercise greater influence in the Asia-Pacific, it must consider the potential devastating impacts of projected climate change in that region. In 2007, we correctly identified that the major projected impacts from climate change in Asia were associated with water: In some areas we suggested there would be too little water, while in other areas (or at different times) there would be too much.

Over the coming decades, projected climate change likely will cause Australia, portions of India, and much of inland China to experience sustained drought, resulting in lowered agricultural production and food security issues. Similarly, many of the major river systems in South Asia are fed by glacial melt, which in the future may not provide enough water to meet year-round demand. A 2012 National Intelligence Council assessment held that water challenges likely will increase the risk of instability and state failure, exacerbate regional tensions, and divert attention from working with the United States and other key allies on important policy objectives.[26]

While drought may be a long-term climate change challenge in Asia, too much water is a problem in the near term. Larger monsoons are becoming an increasing threat to the region, rather than a seasonal source of water for the region's agriculture. Typhoons are now a year-round phenomenon hitting China's coastal region and the Philippines with greater frequency and intensity—witness the destructive force of Typhoon Haiyan in 2013. Warmer oceans mean heavier downpours. As the sea level rises, storm surges will become more invasive, more destructive, costlier, and deadlier. Densely populated areas, including many large cities along coasts or major waterways are particularly vulnerable to monsoon and storm surge flooding:



- Asia has 15 of the world's 20 largest urban areas, including Tokyo, Jakarta, Mumbai, and Dhaka, and most are on the coast or alongside low-lying deltas.
- Burgeoning cities put enormous pressure on urban infrastructure—pressure that is only exacerbated by the effects of climate change, such as flooding.
- Low-lying nations, such as Bangladesh, and entire island countries, such as the Maldives and Kiribati, face existential threats in the near term from sea level rise and devastating storm flooding.
- Projected sea level rise will put critical regions at risk, including the entire Mekong Delta, eastern India, and Bangladesh, which combined produce the bulk of the region's primary food staple, rice.

While many of these areas have battled episodic flooding for decades, two important changes have occurred since the 2007 MAB report. The first is accelerated interdependence. "Just-in-time logistics" are more dependent on transport hubs like Singapore or parts manufacturers in Thailand, Indonesia, and China. Sustained flooding in these countries has occasionally

Asia has 15 of the world's 20 largest cities, including Tokyo, Jakarta, Mumbai, and Dhaka, and most are on the coast or alongside low-lying deltas.

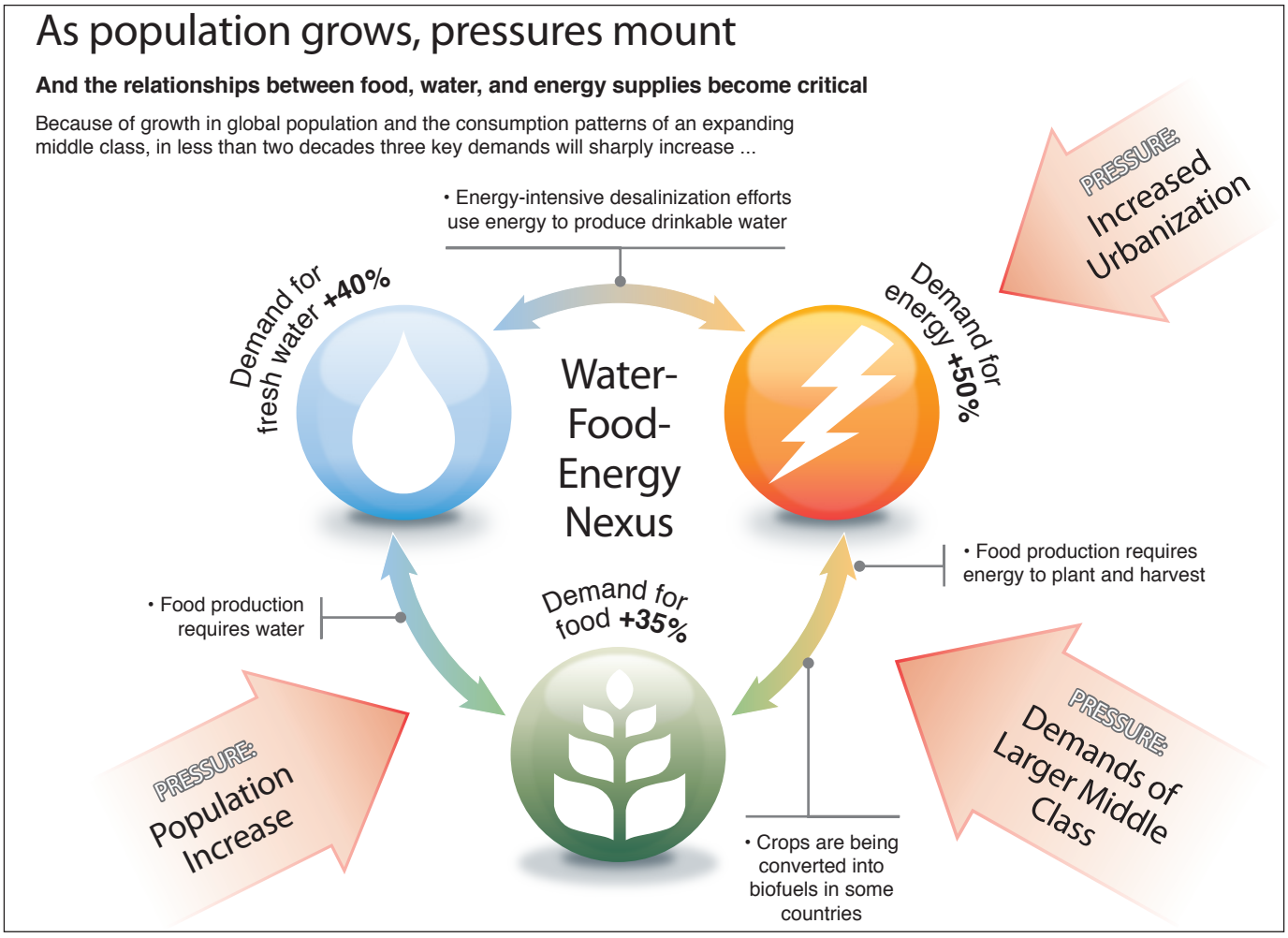
shut down supply chains for manufacturers on the other side of the world until the flood waters subsided. Second, the United States is bolstering its security cooperation with Asian countries as part of its "rebalancing" of forces; HA/DR operations likely will increase in the U.S. Pacific Command's AOR and more countries in the region likely will reach out for assistance following weather-related disasters. In a recent Atlantic Council speech, Admiral Locklear, Commander of U.S. Pacific Command (PACOM), reported that he tells commanders when they join PACOM that they might not engage in a conflict with another military during their tenure, but that they will inevitably have a natural disaster to contend with, and they will have to assist or manage the consequences. "That has been true every year," he said.[27]

Water-Food-Energy Nexus

If the world is going to feed and sustain eight billion people by 2025, achieving collective security for water, food, and energy is critical. The U.S. National Intelligence Council's *Global Trends 2030: Alternative Worlds* found that, because of increases in the global population and the consumption patterns of an expanding global middle class, in less than two decades demand for food would increase by 35 percent, freshwater by 40 percent, and energy by 50 percent.[28] Over the next few decades the areas with the highest levels of population growth are those already suffering from freshwater shortages. Also, the projected impacts of climate change are most profound in areas where the water-food-energy nexus is already stressed.

... the projected impacts of climate change are most profound in areas where the water-food-energy nexus is already stressed.

It is increasingly clear that water, food, and energy are inextricably linked. Water is needed not only for human sustenance, but also for agriculture and energy production. Food production requires water to grow crops and energy to plant and harvest—and to make energy-rich fertilizers. In some parts of the world, forests are burned to produce charcoal, and crops are converted to biofuel instead of food. In other parts of the world, energy-intensive desalinization uses fuel to make freshwater. As major waterways flow across national boundaries, and food grown in temperate areas is shipped to feed millions in dry, poor growing areas, trans-boundary cooperation in ensuring food and water security becomes increasingly important. Isolated solutions aimed at just one sector of the water-food-energy nexus may have unintended or even fatal consequences in other sectors.



The Arctic: An Area of Special International and Domestic Emphasis

As Arctic ice diminishes, the region offers a newly accessible abundance of resources—not only energy and fisheries, but also new shipping routes and even tourism. Geologists estimate that more than one-tenth of the world's undiscovered oil and one-third of the undiscovered gas lie under the waters of the Arctic. We expect more activity of all kinds in the region as the ice continues to retreat and energy and other resources become more accessible. As one of only eight nations with territory north of the Arctic Circle, the United States holds a tangible security interest in the region's future.

Over the past seven years, the Arctic has witnessed unprecedented change. Studies confirm that the mass and volume of old ice in the Arctic is rapidly decreasing.[29] Surface, or *young* ice, comes and goes each year—sometimes increasing, sometimes decreasing—but the newly formed young ice is typically less than 30 centimeters thick and is not a significant safety hazard for most ships. Even ice that has been in place for a year rarely grows beyond 1 to 2 meters and is relatively soft due to the inclusion of brine cells and air pockets.[30] It is the old, hardened, thick ice that has been a traditional barrier to shipping and human activity, and it is this old ice that is rapidly disappearing.

Because of the changes in Arctic ice coverage, we already are seeing increases in human activity, resource extraction, maritime transit, fishing, and tourism in this region of the world. Transiting through the Arctic reduces the sailing distance

Voices of Experience

ADMIRAL FRANK L. "SKIP" BOWMAN, USN (Ret.)
Former Director, Naval Nuclear Propulsion Program

Former Deputy Administrator for Naval Reactors,
National Nuclear Security Administration, U.S. Department of Energy

On Opening of the Arctic

Having served over 38 years in the nuclear submarine community, including over eight years as the head of the Navy's nuclear propulsion program, Admiral Bowman acknowledges and is proud that he has been molded by the principles espoused by the "Father of the Nuclear Navy," Admiral Hyman Rickover. As Rickover's third successor, Admiral Bowman describes the key tenets among these principles as:

- Face facts.
- Respect even small amounts of risk.
- Adhere to the concept of total responsibility.
- Require continual rising standards of performance.

It is through this lens that Admiral Bowman views the rapidly evolving roles and missions of the Department of Defense and the Department of Homeland Security in the Arctic. "As access continues to improve and expand in the area," he notes, "there will be an upward spiral of new opportunities for natural resource exploration and recovery, increased shipping traffic, and a need for broadened naval partnerships and cooperation." He further identifies an increase in risk: "Expect increased calls for search-and-rescue operations and disputes over territorial waters and Exclusive Economic Zones to continue with higher frequency." Admiral Bowman notes "with jaundiced eye" the Russians' planting of a titanium flag on the Artic seabed, near the North Pole: "The geopolitical situation is ever more nuanced and complex. The risk of maritime events, or even unpredictable flashpoints, endemic to national security is growing."

To their credit, Admiral Bowman said, the Department of Defense and the Department of Homeland Security are acknowledging this growing risk—at least on paper. Several recent planning documents have been issued, including the National Strategy for the Arctic Region and its Implementation Plan; the Department of Defense Arctic Strategy; the U.S. Navy Arctic Roadmap for 2014 to 2030; and the U.S. Coast Guard Arctic Strategy. But in looking at responsibility for U.S. national security, Admiral Bowman is increasingly concerned that, "the United States, in particular the Navy and Coast Guard, is woefully ill prepared to execute the anticipated plethora of mission requirements in the Arctic."

"The Navy," he observes, "has precious few ice-hardened vessels to apply to the task, with the exception of nuclear submarines that are poorly suited for most Arctic missions. As a result, it has allowed its Arctic and cold-weather training to atrophy. The Coast Guard has but one fully ready icebreaker in its inventory, and even it represents old technology." In addition, he said, "U.S. land-based infrastructure to support Arctic operations is lacking. The ability to communicate is hampered and limited in Arctic regions, and new technology is only slowly being applied to the problem." He also laments that accurate nautical charts in the polar region are limited, describing how even nautical charts around Alaska show large areas that have never been surveyed with modern instruments.

Admiral Bowman worries that the recent outpouring of Arctic planning documents, while well-intentioned, may paint too rosy a picture of our Arctic capability or the ease of achieving that necessary capability. He cited Admiral Rickover's frequent railings over reactor concepts that were not yet built, calling them "paper reactors." Admiral Bowman remarked, "Rickover would note that these reactors had much in common: they typically were simple, small, cheap, lightweight, could be built quickly, with little research and development, because they could use off-the-shelf technology, and … they were not being built."

Admiral Bowman worries the Arctic planning documents lay out a "paper" way ahead, noting that the United States is not yet building the capacity envisioned. Without the assets, he said, "the U.S. cannot begin the requisite training and qualification that will bring the rising standards of performance that Admiral Rickover demanded." Admiral Bowman concludes that hard work and difficult decisions lie ahead, especially at this "exactly wrong time" to take on added missions in the face of budget cuts, downsizing, and restructuring throughout the military.

between Asian ports and Northern Europe by 40 percent and can save shippers thousands of dollars in fuel costs and emissions. In 2006, while researching our first report the MAB found that few ships were operating in the Arctic and none routinely transited. In 2013, Russia granted 372 permits to transit the Arctic via the Northern Sea Route along its Siberian coastline. This figure represents nearly a tenfold increase from the 46 permits granted in 2012, and nearly a hundredfold increase over the four granted in 2011. While only 71 of these ships actually conducted a full transit across the Arctic, they included commercial cargo vessels from China and Korea, as well as other non-Arctic nations, for the first time. In 2013, a Danish-owned, coal-laden cargo ship sailed through the Northwest Passage, north of Canada—the first-ever commercial transit of this passage.

In addition to transit, more than 1,000 vessels traveled into the High Arctic in 2013 for operations primarily associated with Russian energy development. Geologists estimate that more than one-tenth of the world's undiscovered oil and one-third of the undiscovered natural gas lie under the waters of the Arctic. We expect more vessels of all kinds in the region as the ice continues to retreat and energy and other resources become more accessible.

We are encouraged to see U.S. policymakers preparing for the changing Arctic. Planning documents now cover the full spectrum of strategic and operational concepts of operations (CONOPS) in the Arctic, including: the National Strategy for the Arctic Region and its Implementation Plan; the Department of Defense Arctic Strategy; the U.S. Navy Arctic Roadmap for 2014 to 2030; and the U.S. Coast Guard Arctic Strategy.

entrepreneurs and early adopters are already pushing Arctic operations, despite the high risks. In light of the rapid pace of increased ... activity in the Arctic, we are particularly concerned that increased capability is required today...

Although the planning documents are comprehensive, we believe that in some areas the pace of developing capability and capacity is too slow. While we recognize that well-established shipping companies may not divert significant portions of their fleet through the Arctic anytime soon, entrepreneurs and early adopters are already pushing Arctic operations, despite the high risks. In light of the rapid pace of increased shipping and other activity in the Arctic, we are particularly concerned that increased capability is required today to communicate reliably and to conduct search and rescue. We need better charts and navigation aids, communications capability, enhanced disaster response capabilities, and the ability to exercise freedom of navigation.

We are also concerned that the Unified Command Plan splits Arctic responsibility between two Combatant Commands: U.S. Northern Command (NORTHCOM) and U.S. European Command (EUCOM). This division of the area of responsibility (AOR) runs counter to the concept of unity of command and the tenet of total responsibility residing in one commander. This dual responsibility creates unnecessary tension and has negative impacts on the generation of requirements and sourcing of assets. For simplification, unity of command, and timely execution of requirements and sourcing, we recommend NORTHCOM as the sole Combatant Command for the Arctic region.

Although we regard the likelihood of conflict in the Arctic as low, especially in the near term, the long-term geopolitical situation is complex, nuanced, and uncertain. Maritime issues involving existing and potential claims of the extended outer continental shelf and shipping routes already exist. As a warming planet affords increased access to the Arctic, the MAB cannot rule out new disputes arising over natural resource exploration and recovery, fishing, and future shipping lanes.

The international framework for resolving complex maritime issues is the UN Convention on the Law of the Sea (UNCLOS) treaty, which provides the framework for maritime partnership and cooperation. Since the United States is not a party to UNCLOS, it will be more difficult to have maximum operating flexibility in the Arctic, and it complicates negotiations with maritime partners and other Arctic nations. Moreover, by not being an UNCLOS signatory, the U.S. will have limited or no say in any future changes to UNCLOS.

Voices of Experience

GENERAL PAUL J. KERN, USA (Ret.)
Former Commander, Army Materiel Command

BRIGADIER GENERAL GERALD E. GALLOWAY, USA (Ret.)
Former Dean at the United States Military Academy, West Point

On Infrastructure

When he commanded a brigade at south-central Georgia's Fort Stewart in the 1980s, General Kern found himself dealing with an unexpected threat—wildfires. "It's hard to believe that you can burn a swamp down, but we did," he recalled. With climate change expected to be a cause of future wildfires, among other problems, he and Galloway (who share a background in civil engineering) are concerned about the enhanced risk to the military's infrastructure.

At the same time, General Kern noted that much of the infrastructure on which the DOD relies—roads, bridges, and such—doesn't actually belong to the military. He also said he is concerned about coastal installations that could be vulnerable to sea-level rise, which is considered one of the most serious impacts of a rapidly changing climate.

"We should also be looking at our overseas installations, particularly facilities in Japan along the coast," he said. "One of my concerns is that we get so focused on the continental United States that we don't look outside of our borders."

He said he remembers his experiences serving in Vietnam, "when one of our principal problems was getting supplies ashore. We had hundreds of supply ships not getting in; they were backed up in the harbors."

Brigadier General Galloway praised the Army Corps of Engineers' efforts in collaboration with PACOM in helping with long-range planning in the Mekong River Basin affecting Vietnam and other nearby nations. He said Vietnam's coast is disappearing much like the Mississippi Delta, and that as flooding affects that region's rice paddies it creates potential food-shortage problems that are a source of instability.

Flooding at home also is a major potential worry for General Galloway, a past president of the American Water Resources Association. He testified before the U.S. Senate's Energy and Natural Resources Committee's panel on water and power last year about how climate change, combined with population increases, will affect the nation's aging water and sewer lines, dams, and related infrastructure.

"Structures designed to protect against current or past flooding and coastal erosion threats may not be able to stand up against the forces of larger events, or deal with the increased magnitude of these events," he warned in his testimony. "Increases in population will in many cases require current water and wastewater systems to be not only upgraded but also to be sized to the increased demands that will be expected. Additional surface or subsurface storage may be required, and older facilities may not be in a position to be modified or expanded. Major storm flows, which are currently stressing many existing dams and levees, may increase even more under climate change and further threaten those that rely on these structures."

General Kern said that New York City's experience with flooding during Superstorm Sandy reinforced his belief that military planners should take particular interest in guarding against the threats to communications lines, backup supplies, and anything else located in basement areas. "The message there is, look carefully at what you've got below ground in the areas where there's potential for flooding," he said.

Both Kern and Galloway hope there can be sustained political momentum to address the issue. "There's a saying that the half-life of a memory of a flood is relatively short," General Galloway said. "When your house is patched up and the clamor has stopped about funding, you can get into the 'It probably won't happen here again' mindset. The military can't afford to have that happen."

III. Domestic Implications of Climate Change

- **Projected climate change impacts within the United States will place key elements of our National Power at risk and threaten our homeland security.**
  - **The projected impacts of climate change can be detrimental to military readiness, strain base resilience both at home and abroad, and may limit our ability to respond.**
  - **The projected impacts of climate change can be detrimental to the physical components of infrastructure and information systems, while also limiting their capacities.**
  - **The projected impacts of climate change will threaten major sectors of the U.S. economy.**
  - **The projected impacts of climate change will threaten major sections of our society and stress social support systems such as first-responders.**

The 2014 National Climate Assessment predicts that in the U.S. there will be "increasingly frequent and intense extreme heat, which causes heat-related illnesses and deaths and, over time, worsens drought and wildfire risks, and intensifies air pollution; increasingly frequent extreme precipitation and associated flooding that can lead to injuries and increases in marine and freshwater-borne disease; and rising sea levels that intensify coastal flooding and storm surge."[31] While some changes associated with climate change will bring benefits, like longer growing seasons, many will have detrimental effects because our systems and institutions were built to operate based on historical conditions and geographical settings, not on projected future scenarios.

Military

The military's fundamental purpose is to protect the homeland, build security globally, protect power, and win our nation's wars. We agree with DOD's 2014 QDR that climate change may increase the frequency, scale and complexity of future military missions. Yet the MAB resolves that we should not build our military forces merely to respond to the projected impacts of climate change. Instead, our forces must be ready to meet the full mission set. In this context, readiness is measured by having sufficient numbers of service men and women who are properly trained, equipped, and organized to execute the mission. We are increasingly concerned that projected climate changes have the potential to stress many of the components that contribute to readiness. We expect that projected climate change impacts will:

- Likely increase demand for Guard, reserve, and active forces in response to extreme weather events, natural disasters, and a wider range of Defense Support to Civilian Authorities (DSCA) inside the U.S., potentially restricting the ability of the military services to respond to other simultaneous or subsequent missions.
- Require that we improve training flexibility to accommodate increasingly challenging climate change–related barriers.
- Challenge our bases and surrounding communities, where failure to change and build the necessary resilience could limit our ability to generate readiness and deploy forces.
- Challenge public and DOD-owned logistic infrastructure and transportation systems needed to provide "just-in-time" logistics and equip forces. "Just-in-time" logistics requires the movement of material to a specific location just before the material is needed in the operational or training process.

Maintaining readiness in a constrained budgetary environment is already on the minds of military leaders. In his forwarding letter for the 2014 QDR, Secretary of Defense Hagel describes "the need for tough choices in a

Voices of Experience

VICE ADMIRAL LEE GUNN, USN (Ret.)
Former Inspector General, Department of the Navy

GENERAL DON HOFFMAN, USAF (Ret.)
Former Commander, Air Force Materiel Command

On Energy Efficiency and Innovation

When Admiral Gunn thinks about climate change, he remembers a plaque on the desk of the late Vice Admiral Paul Butcher, a gruff, cigar-chomping figure with whom he served in the 1970s: "Lead, follow, or get the hell out of the way."

"That's the kind of the way I feel about this—we need to be leaders," said Admiral Gunn, a 35-year Navy veteran who is president of CNA's Institute for Public Research. He has given numerous speeches about reducing the military's reliance on oil by catalyzing clean energy technology innovation and adoption.

"During the last seven years, it appears that America has begun to surrender world leadership in this collection of issues dealing with climate change and national security," he said. "Ceding this has serious economic and national security implications, and as the U.S. desires to provide security and stability in various parts of the world, the fact that we are ceding our leadership will make it more and more difficult."

Technologies such as wind and solar not only increase energy independence, Admiral Gunn said, but emit far fewer of the greenhouse gases blamed for causing global warming. He said the MAB's other reports on energy and national security offer a clear road map to how the military can lead on the issue.

One way, he said, is to encourage the DOD to work cooperatively with other agencies, as it has with the Department of Energy. He also would like to see more public-private partnerships that echo the successful work that has been done in housing, managing electrification projects, and water purification and conservation.

Vice Admiral Gunn praised the department's move toward increasing its use of biofuels. "That is an example where the DOD can help incubate new advances in technology," he said. "Even if the services don't end up buying enormous amounts of these fuels, providing a market early on in their development that supports financing of these projects is a great contribution."

Reducing dependence on oil also is a serious concern for General Hoffman, who remembers the Air Force reaction during the oil shocks of the late 1970s. "I saw the behavior before and after to address that, and then I see how we're addressing it today, and it's disappointing," he said. "We did some remarkable things back then."

One program from that era that the military could return to, he said, is putting in place incentives in which organizations keep a portion of the energy savings they achieve, with the freedom to plow that money back into training, quality-of-life projects, or any other pressing needs.

"The bottom line was, by paying attention to every energy flow, we really did a lot of great stuff on the bases," he said. "You have to incentivize behavior if you want to make change. And not just incentivize it—you have to incentivize it as close to the point of consumption as you can, so that the airmen or the airmen's kids feel that they benefit from savings. That's what's missing now [from what] I saw in the '70s."

When it comes to energy efficiency, General Hoffman is trying to practice what he preaches. He designed his Wisconsin home for passive solar and has installed photovoltaic panels, as well as geothermal infrastructure.

"I live in an energy laboratory that doubles as my house," he said, laughing. "Net zero is my ultimate goal."

period of fiscal austerity ... including reducing force structure … expanding critical capabilities, modernizing the force, and investing in readiness." The QDR subsequently then warns: "The impacts of climate change may undermine the capacity of our domestic installations to support training activities." The challenge for the U.S. military is not simple: reduce force size, increase capabilities and readiness, fix our bases so climate change will not undermine our training and deployment activities—all in the context of a constrained budget. Unfortunately, we cannot wait 20 years to begin to factor in the projected impacts of climate change in force-shaping decisions. We must add those impacts to the decision matrix today.

Military Capacity

The MAB sees several major areas of potential impact on readiness relating to climate change. Chief among them is the military's overall capacity for mission performance. Response to humanitarian assistance/ disaster response (HA/DR) and other missions related to increases in frequency and intensity of extreme weather events, both at home and abroad, will stress the National Guard, reserves, and Army Corps of Engineers (ACE), and require increased use of active forces in Defense Support of Civil Authorities (DSCA).

To fight and win our nation's most complex wars, the military relies on a "total force" concept and certain capabilities that exist only in the National Guard, reserves, or Army Corps of Engineers. Yet the Guard, reserves, and the ACE already are being called on more frequently to battle wildfires, respond to flooding and major snow events, and move water to drought-stricken areas, at home and abroad. We believe that the increased frequency, duration, and magnitude of these extreme weather events will stress these organizations' capacities and increase the degree to which active forces will be called on in DSCA missions. While response to HA/DR and other related missions should not be a force-sizing parameter for active forces, the increased demand on the Guard, reserves, and ACE must be factored into future war plans. Planners should not assume that all forces will be able to deploy on short notice.

Military Training

A second area of impact from climate change on military readiness is in training. Extreme weather events, including high and low temperatures, drought and floods, high and damaging winds, and heavy or blowing snow have significant impacts on military operations. These impacts include increased risk to life and safety, injury, and a degrading effect on mission performance. In war and other critical operations, commanders are forced to take larger risks during extreme weather because of the mission, although often with less than ideal results. In peacetime training, commanders should not put the lives of their charges at risk because of high temperatures or extreme weather. The concern of the MAB is that changes in weather patterns that will result from projected climate change will lower the number of training days and reduce training opportunities.

If conditions are too dry, there is also an increased risk of wildfires, and certain types of training, such as live fire, high explosive rounds, or the use of tracer rounds will be suspended or require that extraordinary measures be put in place. For example, in Fort Hood, Texas, the use of live rounds and tracer rounds was suspended for so long in 2011 that commanders were forced to use helicopters to drench certain areas with water while pre-positioning fire-fighting equipment, just so soldiers could train with live ammunition. Similarly, at Marine Corps Air Station Miramar in California, live-fire training using high explosive munitions is prohibited because of the wildfire concern. If it is too hot and humid, there is a risk of loss of life due to heat stress/stroke, and that training will be suspended. This is a "black flag," a condition in which non–mission essential physical training and strenuous exercise must be suspended or moved indoors.

In other parts of the country, the MAB believes training days will be reduced by more intense storms and heavier rainfall. Heavy rainfall and low visibility increases risk and makes ineffective the many forms of training where visual feedback is required. Finally, sea-level rise will disrupt our low-lying training facilities, while changes in coastal ecosystems may increase regulatory restrictions on the use of these facilities.

Those charged with operating, maintaining, and building new training facilities must consider the projected impacts of climate change on future training operations. Resilience and training flexibility should be hallmarks of all future state-of-the-art facilities.

Military Infrastructure

Infrastructure is the third area of a readiness-related impact from climate change. Climate change impacts such as drought and sea-level rise will threaten military infrastruc-

ture and, just as importantly, the communities on which military installations rely. The 2014 National Climate Assessment predicts that in the United States, "Coastal infrastructure including roads, rail lines, energy infrastructure, and port facilities including naval bases, are at risk from storm surge that is exacerbated by rising sea level."[32] We have fine-tuned our military to deliver more combat capability with leaner units; accordingly, the degradation of a given base today has much more impact to overall military capability than in the past. Thus the readiness risk is higher now than it was in the past when a debilitating weather phenomena reduces the effectiveness of a given base or individual unit.

It will not be sufficient to harden bases if, for example, all roads leading to the base are impassable due to floods or the entire area is experiencing a power outage due to a water shortage at a power plant's cooling facilities.

Many of DOD's military installations are concentrated in coastal regions of the United States. These facilities are particularly vulnerable to sea-level rise and storm surge. At the same time, the military's long-term use of coastal installations is, in part, dependent on the ability to maintain the continued functioning of coastal ecosystems, which are becoming increasingly threatened by climate change. The 2010 QDR noted that the National Intelligence Council had judged that more than 30 U.S. installations already were facing elevated levels of risk from rising sea levels. Some military bases and communities are already working together to build resilience. Here we highlight the Hampton Roads area of Virginia as one such military/community team addressing the projected impacts of climate change (see page 25).

Making infrastructure resilient requires long lead times, and both the nation and its installations lag behind in identifying the associated risks. Future basing decisions, as well as future Base Realignment and Closure (BRAC) rounds, will have to make climate change a crucial consideration.

In the 2012 DOD Climate Change Adaptation Roadmap (CCAR), officials indicated that the department "is already beginning to incorporate climate considerations into installation-level planning, as well as training plans. The Department is starting to incorporate climate change science and strategic considerations into formal training and education. The Military Services are beginning to explore incorporating climate risk/vulnerability factors into installation development planning processes." The MAB encourages these efforts, but cautions that they are not being undertaken with a sufficient sense of urgency. In times of severe fiscal austerity it is often too easy to focus on the nearest wolf and lose sight of the pack of wolves that looms just beyond.

Impact on Military Logistics and Private Sector Cooperation/Partnerships

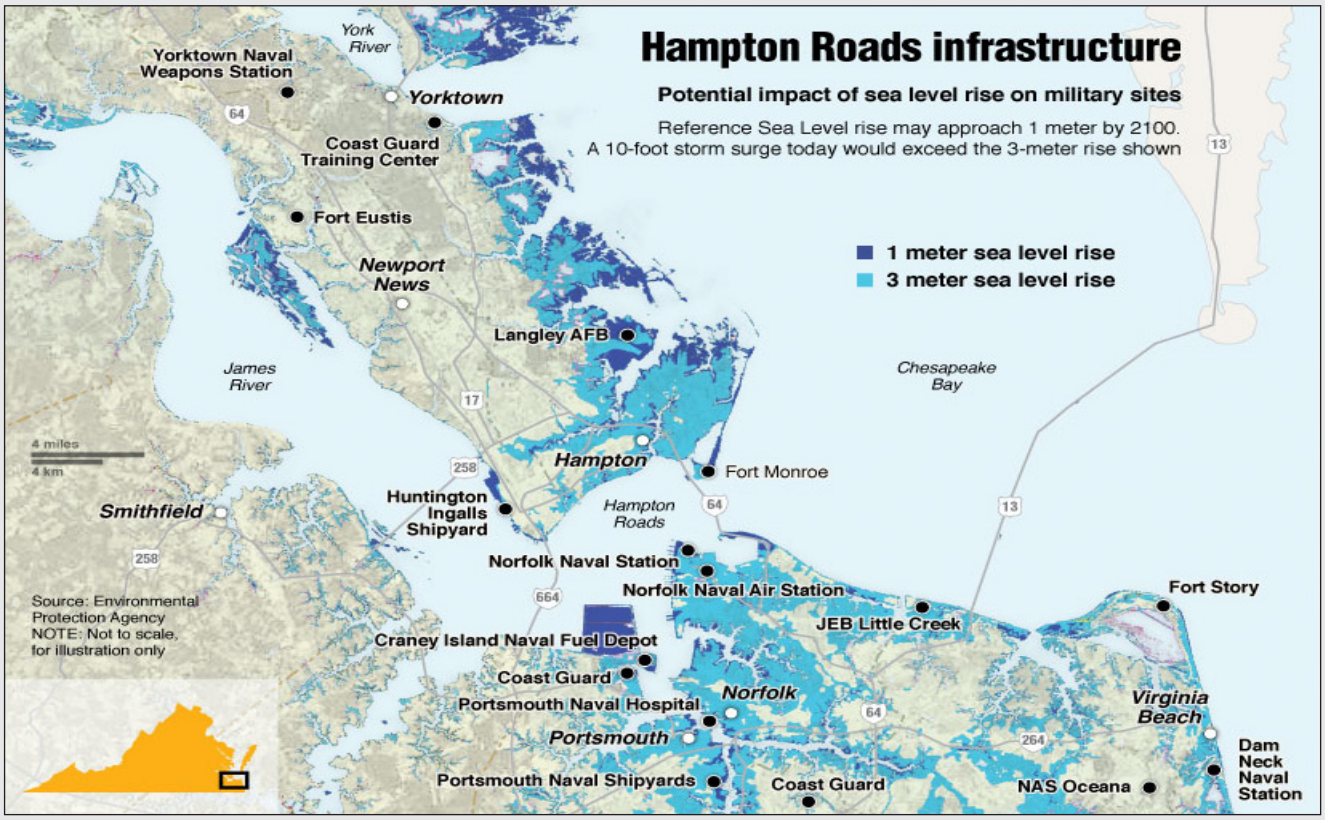
The U.S. military has become a leaner, more efficient force in recent years. The effort to pare down and eliminate redundancy has driven excess spare parts and redundant capacities out of the force, resulting in "just-in-time" logistics support: readiness is now more than ever dependent on the logistics chains and spare parts suppliers shared by the private sector. Climate changes projected to have adverse impacts on private sector infrastructure and logistics systems will have a direct effect on military readiness.

To its credit, the military's efforts in recent years to transition to renewable and efficient energy—such as the Army's "Net Zero" initiatives, the Navy "Green Fleet" and the Air Force Energy Plan—begin to make the military less dependent on traditional fossil fuels. These initiatives make the energy that the military does use more sustainable and productive. Given that the military is the single largest user of oil in the United States (1.7 percent of the U.S. total), it makes sense to continue investing in alternative and renewable energy sources. By reducing our dependence on a single fuel source, such as fossil fuels, these efforts make our bases more operationally resilient and our fighting forces more effective.

The U.S. military will need to adjust to the effects of climate change on its infrastructure, training and testing activities, and acquisition of military capabilities. DOD's operational readiness hinges on continued access to land, air, and sea training and test space, all of which are subject to the effects of climate change. However, in times of budget austerity, it is difficult to balance long-term investment with short-term demands, especially when those short-term demands have national security implications.

One way for DOD to become more resilient at lower cost is to expand the use of public-private partnerships (PPP). Under such partnerships, DOD would conduct a comprehensive assessment of a facility—including the

Case Study: Addressing Sea Level Rise in Hampton Roads



The Hampton Roads area of Virginia is a particularly relevant example to examine the potential impacts of environmental changes on the military and the community. The Hampton Roads metropolitan area is located near the mouth of the Chesapeake Bay in the southeastern part of Virginia. Rising sea levels and storms are of most concern for DOD because of the concentration of military infrastructure and defense industry in the area.

All military branches and the Coast Guard have facilities in the region. In all, there are 29 military sites in Hampton Roads, including Naval Station Norfolk (the largest naval complex in the world), Joint Base Langley-Eustis, Joint Expeditionary Base Little Creek–Fort Story, and Naval Air Station Oceana, including critical defense industry partners such as Huntington Ingalls Shipyard, which builds half our submarines and all of our aircraft carriers. Many of the facilities are at or only a few meters above sea level. Over 20 percent of the United States Navy fleet is homeported in Hampton Roads. It is also a major economic center for Virginia.

The area has hundreds of miles of waterfront from three major rivers that all flow into the Chesapeake Bay. It is an extremely low-lying area, which makes it particularly susceptible to flooding from *relative* sea level rise—a combination of global sea level rise, land subsidence, and ocean circulation. Estimates of relative sea level rise in the Hampton Roads area range from 1.5 feet over the next 20–50 years [33] to as high as a 7.5-foot rise by 2100 (above the 1992 mean sea level baseline).[34]

DOD realizes that the sea level rise will impact not only the Hampton Roads installation, but also the surrounding community. Put simply, DOD may modify roads and bridges, seawalls, piers, runways, and other mission-critical infrastructure on its installations, but the roads and bridges off base that are used by military commuters will also need to be evaluated for potential sea-level-rise impacts and modified as needed. The same holds true for water systems, local airports, local schools attended by military dependents, and other state and local infrastructure. As a result, mitigation solutions cannot be developed and implemented by DOD alone. DOD will need to work with the Commonwealth of Virginia and the Hampton Roads–area local governments to develop a comprehensive strategy.

The White House Council on Environmental Quality (CEQ), the Navy, and other state and federal agencies have initiated a pilot program to assess the impacts of sea level rise. The Climate Change and Sea Level Rise Institute at Old Dominion University is the lead agency, employing a "whole of government" approach to find integrated solutions to sea level rise in Hampton Roads.

impacts of projected climate change—and determine the actions necessary to improve the resilience of the facility. The government could share the necessary resilience development with its private-sector suppliers, realizing potential joint returns on the investment. In such a way, the government can harness the private sector's expertise and efficiencies, while the private sector can make a capital investment with minimal risk and a guaranteed amortization. These types of partnership investments are already being done at bases across the U.S. as a means of lowering the cost of sustainable recapitalization, but it can also be used to lower the cost of building resilience.

National Infrastructure

As are most developed nations, the United States is highly dependent on its critical infrastructure. There are 16 infrastructures identified as critical by Homeland Security Presidential Directive 7, which include energy, water and waste management, communication, defense industrial base, information technology, financial services, nuclear facilities, and transportation systems. Threats to our critical infrastructure threaten all elements of our National Power—from security to the economy to the availability of vital goods such as food, water, and health services. We assess that projected climate change has the potential to impact the full range of our critical infrastructure systems.

We are already seeing the effects of a changing climate on critical systems. In the South and Western U.S., extreme heat is already damaging roads, rail lines, and airport runways.[35] Similarly, warming of the permafrost in Alaska has disrupted power lines, pipelines, and other infrastructure, while the loss of coastal sea ice makes the Alaskan coast vulnerable to storms, coastal erosion, and damage to coastal roads and structures.[36] In the past six years, droughts and higher temperatures have resulted in insufficient cooling water, requiring the shutdown of power generating plants in Texas, Georgia, and Connecticut. In the coming decades, extreme heat will increase demand on our electrical power grids, and more droughts will threaten the water supplies of our electrical power generation stations.

... projected climate change has the potential to impact the full range of our critical infrastructure systems.

In 2012, Superstorm Sandy provided tragic insight on the effects of higher sea levels and storm surge on vulnerable infrastructure. Coming in at high tide, Sandy's storm surge submerged Manhattan's Battery Park under 13.88 feet (4.2 meters) of water and disrupted public and private services across New York City. It flooded seven subway tunnels under the East River and electrical substations, shutting down New York's Financial District. Millions of residences and offices in Manhattan lost power. In Queens, a fire destroyed 111 homes and damaged 20 more when first responders were overwhelmed and hampered by failed infrastructure. Similarly, the 2014 National Climate Assessment estimates that a 1.5 foot rise in sea level would expose property valued in the trillions of dollars to costal flooding in the Baltimore, Boston, New York, Philadelphia, and Providence, RI metropolitan areas. It further estimates that without substantial investments in adaptability and resilience, a two foot sea-level rise would flood 212 miles of roads, 77 miles of rail, 3,647-acres of airport facilities, and 539-acres of runways in New York alone.[37]

The Department of Homeland Security (DHS) is responsible for coordinating actions necessary to manage risks associated with our critical infrastructure. To meet this responsibility, DHS works closely with the private sector, which owns and operates the majority of the nation's critical infrastructure, as well as with state and local governments, which control much of the rest. To coordinate across these stakeholders, DHS uses the National Infrastructure Protection Plan (NIPP) as a framework to integrate climate change risk and required adaptation into resilience and reporting activities already taking place.

In the context of operating environments, cross-sector partnerships require planning factors to guide the collective efforts of critical infrastructure stakeholders. The national effort to strengthen critical infrastructure security and resilience depends on the ability of public and private critical infrastructure owners and operators to make risk-informed decisions when allocating limited resources in both steady-state and crisis operations. However, the NIPP lacks a common analytic baseline of projected climate change that leverages the best available science and clarifies the anticipated conditions regionally and nationally; nor does the NIPP provide regional or sector-specific planning scenarios to allow decisions related to infrastructure resilience.

To inform infrastructure preparedness and resilience activities, the DHS and its NIPP draw on the guidance of the Strategic National Risk Assessment (SNRA). The SNRA evaluates the risk from known threats and hazards that have the potential to significantly impact the nation's homeland security. The SNRA uses data and information from a variety of sources, including existing government models and assessments, historical records, structured analysis, and judgments of experts from different disciplines. It does not use projected climate change impact in its risk assessment. While the risks associated with climate change may seem distant, the decisions being made today pertain to an infrastructure lifecycle that spans many decades—even beyond the end of this century. Consequently, the projected impacts of climate change must be factored into the SNRA and NIPP now.

While the risks associated with climate change may seem distant, the decisions being made today pertain to an infrastructure lifecycle that spans many decades...

Economic

According to the 2014 National Climate Assessment: "There is mounting evidence that harm to the nation will increase substantially in the future unless global emissions of heat-trapping gases are greatly reduced."[38] For example, an increasing percentage of the U.S. population and economic assets—including major U.S. cities and financial hubs such as Miami, Lower Manhattan, New Orleans, and Washington DC—are located on or near coasts, and they are threatened by sea-level rise. The cost of protecting and building resilience in these assets will be high. Similarly, much of the manufacturing in the U.S. is built along waterways for ease of transportation. These waterways are subject to flooding during extreme precipitation, and they may also become too shallow for navigation during periods of drought. Contributing one percent of the nation's GDP, agriculture will also be impacted by climate change. Prolonged drought and water scarcity will lower agricultural production in most of the U.S. West and South. Warmer temperatures and higher CO_2 levels will increase growing seasons and yields in the Midwest, but this development likely will be offset by heat waves, droughts, and flooding during planting seasons. In short, most U.S. economic sectors will be affected by projected climate change.

Social Support

According to the 2014 National Climate Assessment, "Certain groups of people are more vulnerable to the range of climate change–related health impacts, including the elderly, children, the poor, and the sick. Others are vulnerable because of where they live, including those in floodplains, coastal zones, and some urban areas. In fact, U.S. population growth has been greatest in coastal zones and in the arid southwest, areas that already have been affected by increased risks from climate change."[39] As coastal regions become increasingly populated and developed, more frequent or severe storms will increase the requirements for emergency responders, including federal, state, local, tribal and territorial, to deal with a multitude of hazards impacting communities. Emergency operations and delivery of emergency services will be challenging and made increasingly complex by damage or disruptions to interconnected energy and infrastructure networks, thus limiting response and recovery capacity. Severe weather events—possibly accompanied by mass displacement, ensuing pandemics, or degraded critical infrastructure—will increasingly outstrip normal government resources and require increased use of active duty military and resources from the private sector.

Projected climate change in the United States over the coming decades may result in simultaneous extreme weather events or cascading natural disasters that will demand significant deployments of military forces across regions of the U.S. They may be called to battle wildfires, assist with flood control, move debris and clear roads, provide relief or humanitarian assistance, protect vital infrastructure, or control crowds or masses of people. The extent to which military forces will be used to protect the homeland in response to projected climate change impacts should not be limited by our past history of military deployments or limited by failures of imagination. Accordingly, systems should be put in place and tested now to ensure that we can optimize DSCA by integrating military forces seamlessly into federal, state, and local responders, and coordinate these support activities with centralized command and control facilities.

IV. Summary

Concern over the potential for climate change impacts on our national security—regardless of the cause—has diminished as a national issue, and politically charged debate has silenced sound public discourse. As members of the MAB we believe that congressional action is warranted—and it is needed now. Neither the DOD, nor any other agency, can act alone to address the impacts of climate change.

The MAB believes that concerns over the potential impacts of our changing climate can offer the potential to bring diverse stakeholders and communities together to devise effective solutions. Cooperation will be especially important in an era in which military budgets, like many others across government, will be severely constrained. Planning for the future of America's military must factor in both the limitations on readiness accompanying climate changes and the profusion of demands for military support resulting from climate and weather-related conditions and events.

We who have served on the MAB are concerned that while the causes of climate change and its impacts continue to be argued or ignored in our nation, the linkage between changes in our climate and national security has been obscured. Political concerns and budgetary limitations cannot be allowed to dominate what is essentially a salient national security concern for our nation. Our Congress, the administration, and all who are charged with planning and assuring our security should take up the challenge of confronting the coming changes to our environment. Prepare our instruments of National Power to continue to serve the American people well as the world around us changes. Take steps to limit climate changes where possible; for everything else, factor those changes into all our choices about America's future national security.

Our specific recommendations are provided in the Executive Summary to this report.

Appendix: CNA Military Advisory Board Biographies

GENERAL PAUL J. KERN, USA, (Ret.)

Former Commanding General, U.S. Army Materiel Command

Chairman, CNA Military Advisory Board

General Kern was Commanding General, Army Materiel Command from 2001 to 2004, and Senior Advisor for Army Research, Development, and Acquisition from 1997 to 2001. He was commissioned as an Armor Lieutenant following graduation from West Point in 1967, and served three combat tours—two in Vietnam as a platoon leader and troop commander, and the third in Desert Shield/Desert Storm. In the 1990s, Kern served as Senior Military Assistant to Secretary of Defense William Perry. In June 2004, at the request of Secretary of Defense Donald Rumsfeld, Kern led the military's internal investigation into the abuses at the Abu Ghraib prison in Iraq.

He holds master's degrees in both Civil and Mechanical Engineering from the University of Michigan, and he was a Senior Security Fellow at the John F. Kennedy School at Harvard University.

ADMIRAL FRANK "SKIP" BOWMAN, USN (Ret.)

Former Director, Naval Nuclear Propulsion Program;

Former Deputy Administrator–Naval Reactors, National Nuclear Security Administration

For over eight years, Admiral Skip Bowman was Director, Naval Nuclear Propulsion, Naval Sea Systems Command and concurrently Deputy Administrator for Naval Reactors in the Naval Nuclear Security Administration, Department of Energy; additionally as a flag officer, Admiral Bowman served as Chief of Naval Personnel and as Director for Political-Military Affairs and Deputy Director for Operations on the Joint Staff.

He was commissioned following graduation in 1966 from Duke University. In 1973, he completed a dual master's program in nuclear engineering and naval architecture/marine engineering at the Massachusetts Institute of Technology and was elected to the Society of Sigma Xi. Admiral Bowman has been awarded the honorary degree of Doctor of Humane Letters from Duke University.

Admiral Bowman was President and CEO of the Nuclear Energy Institute from 2005 through 2008. NEI is the policy organization for the commercial nuclear power industry. In 2006, Admiral Bowman was named an Honorary Knight Commander of the Most Excellent Order of the British Empire by Queen Elizabeth. Admiral Bowman currently serves on the boards of directors of BP and Morgan Stanley Mutual Funds.

GENERAL JAMES T. CONWAY, USMC (Ret.)

Former Commandant of the Marine Corps

As Commandant, General Conway served as the senior uniformed Marine responsible for the organization, training, and equipping of over 250,000 active duty, reserve, and civilian personnel serving in the United States and overseas. He managed an annual budget on the order of $40 billion. As a member of the Joint Chiefs of Staff for four years, he was as a military advisor to the Secretary of Defense, the National Security Council, and the President. Previous high-level assignments included President of the Marine Corps University, command of a (20,000 Marine) Division, and commander of 90,000 U.S. and British forces during the invasion of Iraq. Prior to becoming the Commandant, he served as the J-3 Joint Staff, or senior operations officer, in the U.S. military, where he oversaw the war efforts in Iraq and Afghanistan.

He attended Southeast Missouri University; the Seminar XXI M.I.T. Fellowship Program, and the JFK School of Government, Harvard University, Seminar on International Relations.

LIEUTENTANT GENERAL KEN EICKMANN, USAF (Ret.)

Former Commander, Aeronautical Systems Center, Wright-Patterson AFB

From 1996 to 1998, General Eickmann served as the Commander, Aeronautical Systems Center, Wright-Patterson AFB, where he led the nation's largest center of excellence for research, development, and acquisition of aircraft, aeronautical equipment, and munitions. General Eickmann was the Commander of the Oklahoma City Air Logistics Center and Installation Commander of Tinker Air Force Base from 1994 to 1996; Deputy Chief of Staff for Logistics and Chief of Staff for Air Force Materiel Command from 1992 to 1994; and DCS Logistics, Headquarters Pacific Air Forces from 1990 to 1992. The general served six years on the Air Force Science and Technology Board and has chaired numerous energy-related

studies for the National Academy of Sciences and the National Research Council. He is a recognized expert in energy, logistics, and propulsion technology, and has published several papers in technical journals in the U.S. and overseas.

Ken Eickmann is currently the Deputy Director of the Center for Energy Security at the University of Texas in Austin. He holds a bachelor's degree in Mechanical Engineering from UT Austin, a master's degree in Systems Engineering from the Air Force Institute of Technology, and is a graduate of the University of the Michigan School of Business and the John F. Kennedy School of Government, Harvard University.

LIEUTENANT GENERAL LAWRENCE P. FARRELL JR., USAF (Ret.)

Former Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force

In 1998, General Farrell served as the Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force, Washington, DC. He was responsible for planning, programming, and manpower activities within the corporate Air Force and for integrating the Air Force's future plans and requirements to support national security objectives and military strategy. Previous positions include Vice Commander, Air Force Materiel Command and Deputy Director, Defense Logistics Agency. He also served as Deputy Chief of Staff for Plans and Programs at Headquarters U.S. Air Forces in Europe. A command pilot with more than 3,000 flying hours, he flew 196 missions in Southeast Asia, and commanded the 401st Tactical Fighter Wing, Torrejon Air Base, Spain.

General Farrell is a graduate of the Air Force Academy with a BS in Engineering and an MBA from Auburn University. Other education includes the National War College and the Harvard Program for Executives in National Security.

BRIGADIER GENERAL GERALD E. GALLOWAY JR., USA (RET.),

Former Dean at the United States Military Academy, West Point

Former Dean at the Industrial College of the Armed Forces, National Defense University

Vice Chairman, CNA Military Advisory Board

Brigadier General Gerry Galloway served for 38 years as a combat engineer, civil engineer, and a military educator in various command and staff assignments in Germany, Southeast Asia, and the United States before retiring in 1995. He is currently a Glenn L. Martin Institute Professor of Engineering and an affiliate Professor of Public Policy, University of Maryland, where his research focuses on disaster risk management and the impacts of climate change in the U.S. and internationally. He commanded the Corps of Engineers Vicksburg Engineer District and was a Presidential appointee to the Mississippi River Commission from 1988 to 1995. From 1994 to 1995, he was assigned to the White House to lead a committee in assessing the causes of the 1993 Mississippi River flood. In 2006 he chaired an Interagency National Levee Policy Review Team. Since 2010 he has served on the Governor of Louisiana's Advisory Commission on Coastal Protection and Restoration.

He is a graduate of the U.S. Military Academy and holds master's degrees from Princeton University, Pennsylvania State University, and the U.S. Army Command and General Staff College, and a doctorate from the University of North Carolina at Chapel Hill. He is a member of the National Academy of Engineering, has served on thirteen committees of the National Research Council, chairing two studies of future Army Logistics, and is a member of the National Academies Roundtable on Risk, Resilience, and Extreme Events.

VICE ADMIRAL LEE F. GUNN, USN (Ret.)

Former Inspector General of the Department of the Navy

Vice Chairman, CNA Military Advisory Board

Vice Admiral Lee Gunn served for 35 years in U.S. Navy. His last active duty assignment was Inspector General of the Department of the Navy, where he was responsible for the Department's overall inspection program and its assessments of readiness, training, and quality of service. Serving in the Surface Navy in a variety of theaters, Gunn rose through the cruiser/destroyer force to command the frigate USS BARBEY, then commanded the Navy's anti-submarine warfare tactical and technical evaluation Destroyer squadron, DESRON 31. He later commanded Amphibious Group Three. As Commander of PHIBGRU THREE he served as the Combined Naval Forces Commander, and Deputy Task Force Commander of Combined Task Force United Shield, which conducted the withdrawal of U.N. peacekeeping forces from Somalia.

Gunn holds a bachelor's degree in Experimental and Physiological Psychology from the University of California, Los Angeles, and a Master of Science degree in Operations Research from the Naval Postgraduate School in Monterey, California.

CNA Military Advisory Board Biographies (cont.)

GENERAL DONALD J. HOFFMAN, USAF (Ret.)

Former Commander, Air Force Material Command

General Hoffman retired in June 2012 after managing a workforce of 80,000 with a $60 billion budget to develop, acquire, test and sustain Air Force weapon systems. He also served as the Military Deputy for Air Force Acquisition in the Pentagon and the Director of Requirements at Air Combat Command. He is a pilot with over 3,800 hours in fighter, trainer, and transport aircraft, and has served in numerous operational commands.

A graduate of the U.S. Air Force Academy, General Hoffman has a Master's Degree in Electrical Engineering from the University of California, Berkeley, and has attended National War College and the National Security Management Course at Syracuse University.

GENERAL RONALD E. KEYS, USAF (Ret.)

Former Commander, Air Combat Command

General Ron Keys retired from the Air Force in November 2007 after a career of over forty years. His last assignment was as Commander, Air Combat Command, the Air Force's largest major command, consisting of more than 1,200 aircraft, 27 wings, 17 bases, and 200 operating locations worldwide with 105,000 personnel. General Keys holds a Bachelor of Science from Kansas State University and a Master's degree in business administration from Golden Gate University. General Keys is a command pilot with more than 4,000 flying hours in fighter aircraft, including more than 300 hours of combat time.

No stranger to energy challenges, General Keys first faced them operationally as a young Air Force Captain, piloting F-4s during the fuel embargo of the 1970s. Later, as Director of Operations for European Command, fuel and logistic supply provisioning were critical decisions during humanitarian, rescue, and combat operations across EUCOM's area of responsibility, including the Balkans and deep into Africa. As Commander of Allied Air Forces Southern Europe and Commander of the U.S. 16th Air Force, similar hard choices had to be made in supporting OPERATION NORTHERN WATCH in Iraq, as well as for combat air patrols and resupply in the Balkans. Later, as the Director of all Air Force Air, Space, and Cyber mission areas, as well as operational requirements in the early 2000s, he saw the impact of energy choices on budget planning and execution, as well as in training and supporting operational plans in Iraq and Afghanistan. Finally, at Air Combat Command, he faced the total challenge of organizing, training, and equipping forces at home and deployed to balance mission effectiveness with crucial energy efficiency. He is a member of the Center for Climate and Security's Climate and Security Working Group focused on developing policy options and encouraging dialogue and education on the issues. As a member of the CNA Military Advisory Board on DOD Energy Security and Climate Change projects, he is intimately familiar with the relationship of energy, military, economic, and national security.

General Keys owns RK Solution Enterprises, an independent consultancy. In addition to his energy portfolio, he is a Senior Advisor to the Bipartisan Policy Center, and a Member of the Embry-Riddle Aeronautical University Board of Trustees.

REAR ADMIRAL NEIL MORISETTI, BRITISH ROYAL NAVY (Ret.)

Former UK Foreign Secretary's Special Representative for Climate Change

Former Commandant, UK Joint Services Command and Staff College

Rear Admiral Neil Morisetti retired from the Royal Navy in December 2012, after 36 years of service. His last active duty appointment was as the UK Government Climate and Energy Security Envoy, where he engaged with policymakers around the world to address the security implications, national and global, of a changing climate. Prior to that, his flag posts included Commandant of the UK Joint Services Command and Staff College, where he was responsible for the military postgraduate education of students from 60 nations, and Commander of UK Maritime Forces (deployable fleet commander). A Surface Warfare Officer, his ship commands ranged in size from the patrol boat HMS CYGNET to the aircraft carrier HMS INVINCIBLE.

In 2013 he served as the UK Foreign Secretary's Special Representative for Climate Change, charged with working to help set the political conditions for a global agreement on climate change.

A graduate of Britannia Royal Naval College, he has a Bachelor of Science degree in Environmental Sciences from the University of East Anglia and is an Honorary Professor at University College London where he is Director of Strategy for the Department of Science, Technology, Engineering, and Public Policy.

CNA Military Advisory Board Biographies (cont.)

VICE ADMIRAL ANN RONDEAU, USN (Ret.)

Former President of National Defense University

Former Deputy Commander, U.S. Transportation Command

Vice Admiral Ann Rondeau served for 38 years in the United States Navy. Her last active duty assignment was President, National Defense University. Serving in the Navy during dynamic years of transition, Rondeau served in leadership, staff, and command assignments in myriad mission areas: fleet operations (anti-submarine warfare, air operations, operational intelligence, maritime transportation and sealift), strategy and policy, operations analysis, training and education, business enterprise, and shore installations management. She was selected as a White House Fellow, Chief of Naval Operations Strategic Studies Group Fellow, and served two years at the Department of Justice as National Security Advisor to the United States Attorney General. As President of NDU, she was a member of the Board of Directors of the United States Institute of Peace and served as a Department of Defense liaison to the Center for the Study of the Presidency and Congress. Rondeau is a permanent member of the Council on Foreign Relations, a member of the Board of Directors of the German Marshall Fund, a member of the Board of Trustees of the American Public University System and is a member of the Center for Naval Analyses Military Advisory Board. She has lectured occasionally at George Washington University and the Madeleine K. Albright Institute for Global Affairs at Wellesley College. With keen interest in the full breadth of public policy issues and dignified public discourse and dialogue, she has spoken extensively for many years on myriad subjects and has had the privilege of participating in many different and interesting public engagements.

Rondeau holds a Bachelors Degree in History and Social Science from Eisenhower College (and received the Board of Trustees Groben Award for Leadership), a Masters Degree with Honors in Comparative Government from Georgetown University, a Doctorate in Education (dissertation addressed applied research and public policy) from Northern Illinois University and has attended several senior executive training and education seminars. She is presently a senior executive with IBM's Watson Group (cognitive computing).

LIEUTENANT GENERAL KEITH J. STALDER, USMC (Ret.)

Former Commanding General, U.S. Marine Corps Forces, Pacific

LtGen Stalder was the senior Marine Corps Military Representative to the U.S. Pacific Command for operations in the Pacific, including Japan, China, North and South Korea, Guam, and Okinawa. The largest field command in the Marine Corps, it encompassed the operational forces of I and III Marine Expeditionary Forces. He directed and supervised Marine Corps Bases in Japan, Okinawa, Korea, the western United States, with 90,000 people, 500 aircraft, and 17 Bases and Stations. Previous high-level assignments include command of II Marine Expeditionary Force, Marine Corps Training and Education Command, 3rd Marine Aircraft Wing, and 1st Marine Expeditionary Brigade. LtGen Stalder is a Senior Fellow at the CNA.

He holds an undergraduate and graduate degree in Aeronautics from Embry-Riddle Aeronautical University.

GENERAL GORDON SULLIVAN, USA (Ret.)

Former Chief of Staff, U.S. Army

From 1991 to 1995, General Sullivan served as the 32nd Army Chief of Staff—the senior general officer in the Army—and a member of the Joint Chiefs of Staff. As the Chief of Staff of the Army, he created the vision, and led the team, that transitioned the Army from its Cold War posture.

He was Army Vice Chief of Staff from 1990 to 1991, Army Deputy Chief of Staff, Operations and Plans from 1989 to 1990, and Commander, 1st U.S. Army Infantry Division (Mechanized) from 1988 to 89. From 1987 to 1988 he served as Deputy Commandant, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas; and from 1983 to 1984 was Assistant Commandant, U.S. Army Armor School, Fort Knox, Kentucky. His overseas assignments include four tours in Europe, two in Vietnam, and one in Korea. He served as Chief of Staff to the Secretary of Defense during the administration of President George H. W. Bush.

Sullivan holds a bachelor of arts degree in History from Norwich University and a master of arts degree in Political Science from the University of New Hampshire.

CNA Military Advisory Board Biographies (cont.)

REAR ADMIRAL DAVID W. TITLEY, USN (Ret.)

Former Oceanographer and Navigator of the Navy

Rear Admiral David Titley retired from the Navy in 2012. Dr. Titley is now a senior scientist in the Department of Meteorology at Penn State. He is also the founding director of Penn State's Center for Solutions to Weather and Climate Risk. Dr. Titley served as a naval officer for 32 years, rising to the rank of rear admiral; his career included duties as oceanographer and navigator of the Navy. In 2009, he initiated and led the U.S. Navy Task Force on Climate Change. Titley holds a bachelor of science in meteorology from Penn State. From the Naval Postgraduate School, he earned an MS in meteorology and physical oceanography, and a PhD in meteorology. He was elected a fellow of the American Meteorological Society in 2009.

GENERAL CHARLES F. "CHUCK" WALD, UASF (Ret.)

Former Deputy Commander, Headquarters U.S. European Command

General Wald retired from the U.S. Air Force as a four star general after serving over 35 years in the U.S. military as a command pilot with more than 3,600 flying hours and 430 combat hours. In his last position, he served as deputy commander of U.S. European Command (EUCOM) from 2002 until his retirement from the U.S. Air Force in July 2006. In that role he was responsible for U.S. forces operating across 91 countries in Europe, Africa, Russia, parts of Asia, the Middle East, and most of the Atlantic Ocean. During his command, he developed the European Command Strategic Plan that included energy assurance and sustainment for the EUCOM Area of Responsibility (AOR).

General Wald commanded the 31st Fighter Wing at Aviano Air Base, Italy, where on August 30, 1995, he led one of the wing's initial strike packages against the ammunition depot at Pale, Bosnia-Herzegovina. From 1999 to 2001, he commanded the 9th Air Force and U.S. Central Command Air Forces at Shaw Air Force Base in South Carolina. In September 2001, as the Supporting Commander, General Wald led the development of the coalition air campaign in Operation Enduring Freedom, including the idea of embedding tactical air control parties in ground special operations forces leading to the extraction of Taliban forces in Afghanistan.

General Wald is a command pilot with more than 3,600 fying hours, including more than 430 combat hours over Vietnam, Cambodia, Laos, Iraq, and Bosnia. The general earned his commission through the Air Force ROTC program in 1971. He earned his Master's Degree in International Relations from Troy University and received a Bachelor of Arts degree in pre-law from North Dakota State University. He currently serves as Vice Chairman and Federal Practice Advisory Partner of Deloitte.

LIEUTENANT GENERAL RICHARD C. ZILMER, USMC (Ret.)

Former Deputy Commandant for Manpower and Reserve Affairs, Headquarters Marine Corps

Lieutenant General Richard Zilmer retired from Active Duty in January of 2011 following over 36 years of commissioned service. During his military career, Zilmer served in a variety of operational and staff assignments throughout the United States, the United Kingdom, Germany, and Japan. His operational commands consisted of Commanding Officer First Battalion, First Marines, Commanding Officer 15th Marine Expeditionary Unit, Commanding General Multinational Forces–West (Anbar Province, Iraq) and Commanding General III Marine Expeditionary Force, Okinawa, Japan. Zilmer served combat tours during Lebanon Peacekeeping Operations, Operation Desert Storm, and Operation Iraqi Freedom. Zilmer's staff assignments included multiple Washington DC tours at Headquarters Marine Corps, Deputy J-3 for Operations at the United States European Command. His final assignment was Deputy Commandant for Manpower and Reserve Affairs, Headquarters Marine Corps.

Lieutenant General Zilmer graduated with a bachelor's degree in Secondary Education from Kutztown University in 1974 and holds a master of arts degree in National Security and Strategic Studies from the College of Naval Warfare.

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