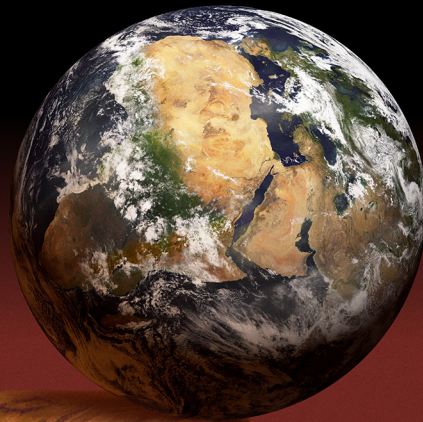


NUCLEAR **WINTER,** NUCLEAR **STRATEGY,** NUCLEAR **RISK**

National Security Perspective



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NUCLEAR WINTER, NUCLEAR STRATEGY, NUCLEAR RISK

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Abstract

In this essay, we strive to explain the long-standing practice of intentionally ignoring the potential for nuclear winter in the formulation of US nuclear strategy. To do so, we explore the critical relationships between (1) nuclear winter and (2) nuclear strategy and nuclear risk. We consider the multiple roles of nuclear weapons and how perspectives on nuclear winter affect these roles. We distinguish cases in which neither, only one, or both sides in an adversarial relationship believe nuclear winter would be cataclysmic. Our analysis reveals two primary reasons for ignoring nuclear winter in US nuclear strategy. First, any single nuclear state can only do so much by itself to reduce nuclear winter's consequences. The second, largely unspoken, reason is that the side believed to be more concerned about the risk of nuclear winter may be at a disadvantage in nuclear crisis management, deterrence, and warfighting. Nevertheless, we argue that prudence dictates we revisit current nuclear strategy. As the risk of nuclear war grows, it is increasingly apparent that we can no longer completely rely on the continued success of deterrence. We must also hedge against its possible failure. The risk of catastrophic nuclear winter must be weighed against the potentially detrimental effects that acknowledging and ameliorating its consequences could have on nuclear strategy.

In this essay, which supplements a companion paper by the same authors,¹ we discuss the relationships between (1) nuclear winter and (2) nuclear strategy and nuclear risk. We are motivated by the disturbing dissonance between those scientists who stridently argue that nuclear winter is a dire threat to humanity and the US government, which has ignored these claims.

We take as a starting point the legitimate scientific uncertainty about the potential severity of a nuclear winter. Much like uncertainty about climate change, which stymied significant policy responses for a considerable time, uncertainty about nuclear winter has also been invoked to justify inaction.² And even now, with a scientific consensus that climate change is real, is anthropogenic, and has dire consequences for the planet, some leaders continue to deny the need for mitigation. Since there is not as solid a scientific consensus about nuclear winter, even some four decades after its discovery, uncertainty remains a significant contributor to complacency in adapting nuclear strategy. However, this is not the whole story or even necessarily the most important part of the story.

While nuclear winter is potentially the most severe consequence of nuclear war, its possibility has had very little—if any—impact on US nuclear strategy.

While scientific predictions of nuclear winter's severity still differ across studies, the essential phenomenology is well understood and accepted: nuclear explosions will ignite fires that, in turn, could—depending on the environs of the

burst—create sooty smoke that could—under the right circumstances—loft into the stratosphere where it will remain for extended periods and attenuate sunlight, cooling the earth's surface, reducing precipitation, and resulting in other climatic and environmental effects. Depending on the character of the nuclear war, this cooling potentially could be extreme (tens of degrees Celsius), threatening modern civilization³ and numerous species with extinction.⁴ Even comparatively minor cooling (one to two degrees Celsius) as projected from regional nuclear scenarios of one hundred low-yield nuclear detonations, could potentially wreak havoc on food security⁵ and the marine ecosystems⁶ that humanity depends on. The small subset of scientists who continue to conduct nuclear winter research are completely convinced of the validity of this description.

But the devil is in the details; there are many caveats in this narrative. Two particular areas of scientific debate are essential to accurate estimates of the consequences: how much material will burn, and how much sooty smoke will loft up to the stratosphere in the variety of plausible and possible scenarios of nuclear war. The uncertainties associated with these and other questions make the difference between a severe nuclear winter and a more moderate one or between a moderate one and a barely perceptible one. While these differences are important, even a moderate nuclear winter could have profound consequences, resulting in worldwide

¹ Proper, Ice, and Scouras, *Whatever Happened to Nuclear Winter?*

² *Climatic, Biological, and Strategic Effects of Nuclear War* (Goure statement); and "Nuclear Winter: View from the US Defense Department."

³ Sagan, "Nuclear Winter."

⁴ Vaughan, Pimm, and Fields, "Extinction Cascade."

⁵ Xia et al., "Global Famine after Nuclear War"; Jägermeyr et al., "A Regional Nuclear Conflict Would Compromise Global Food Security"; Scherrer et al., "Marine Wild-Capture Fisheries after Nuclear War"; Xia et al., "Global Food Insecurity and Famine"; and Hochman et al., "Economic Incentives Modify Agricultural Impacts of Nuclear War."

⁶ Harrison et al., "A New Ocean State after Nuclear War"; Lovenduski et al., "Potential Impact of Nuclear Conflict on Ocean Acidification"; and Coupe et al., "Nuclear Niño Response Observed."

deaths comparable to or exceeding those caused by the more familiar and direct effects of nuclear war.

While nuclear winter is potentially the most severe consequence of nuclear war, its possibility has had very little—if any—impact on US nuclear strategy. To the extent that military and political leaders even think about nuclear winter, many simply dismiss it as a Cold War hypothesis debunked in the late 1980s.⁷ Others rationalize the lack of policy response by claiming that nuclear winter helpfully supports deterrence by making the consequences of nuclear war even more unacceptable to all.⁸

Assessing the impact of the prospect of nuclear war requires distinguishing cases in which neither, only one, or both sides believe nuclear winter would—or could—be cataclysmic.

Moreover, assuming the science behind nuclear winter predictions is valid, it is possible that a nuclear winter could be caused by a relatively small number of nuclear detonations.⁹ It follows that any of the major nuclear powers could, by itself, cause nuclear winter, and that no nuclear power, in isolation, can preclude the possibility of nuclear winter. Rather, the cooperation of all major nuclear powers would be required.

In this essay, we sort through these and related issues. We focus our discussion by asking how the

⁷ Starr, “Turning a Blind Eye towards Armageddon”; and Robock, “Nuclear Winter Is a Real and Present Danger.”

⁸ *Nuclear Winter, Joint Hearings* (Perle statement); Sagan et al., “Comment and Correspondence”; Griffin, “Nuclear Winter and Nuclear Policy”; and Gertler, *Some Policy Implications of Nuclear Winter*.

⁹ A hypothetical nuclear exchange between India and Pakistan of one hundred low-yield (fifteen-kiloton) nuclear weapons has been the focus of recent nuclear winter studies that have projected one to two degrees Celsius cooling.

possibility of nuclear winter affects nuclear deterrence and nuclear risk. We address this question by considering the multiple roles of nuclear weapons and how nuclear winter affects them. We then address the principal risks of considering nuclear winter in US nuclear strategy, as well as the risks posed by the current US practice of ignoring nuclear winter. We conclude with our own perspectives on the need to consider nuclear winter in nuclear strategy.

Roles of Nuclear Weapons

Nuclear weapons have three primary roles. The first and most discussed is to underwrite *deterrence* of nuclear attack against the United States and its allies (often ambiguously broadened to US “vital interests”). This is understood to be accomplished through capability and will—both as we assess to be perceived by our adversaries—to inflict “unacceptable” damage in retaliation for any such attack. Unacceptable damage is scenario dependent and can range from a nonnuclear response to a tit-for-tat nuclear response to a very large nuclear retaliation employing most or all of the available US arsenal.

The second use, *warfighting*, led to the only nuclear attacks in history and reigned supreme in the second half of the 1940s and into the 1950s until the Soviet Union could credibly threaten nuclear retaliatory strikes against the United States. The capability and will to engage in nuclear warfighting with tactical nuclear weapons critically supported defense of European NATO countries in the Cold War against what was then thought to be overwhelming Soviet conventional superiority. Nuclear warfighting has receded in relative importance in the post-Cold War era, primarily due to the ascendance of US conventional military power, except in regional conflicts involving other nuclear powers. Of course, deterrence and warfighting are related. The ability to articulate a credible strategy for nuclear warfighting and underwrite it with sufficient nuclear capability is critical to deterrence.

And if deterrence does fail, one of the primary goals of nuclear warfighting will be to restore it before Armageddon occurs.

Finally, nuclear weapons set the stage for international relations in general, and for *management of crises* between nuclear states in particular. In this role, they are primarily weapons of intimidation, whether kept in the background or overtly brandished. We've seen this most recently in the Russian attack on Ukraine where Russia has gone to great lengths to remind the United States and NATO that it is a nuclear peer and convey the impression that it would escalate the conflict to nuclear use if sufficiently provoked. To avoid such an escalation, the United States has gone to great lengths to not get directly involved and has constrained its military support to Ukraine.

How Does the Prospect of Nuclear Winter Affect These Roles?

Addressing this question requires distinguishing cases in which neither, only one, or both sides believe nuclear winter would—or could—be cataclysmic. More subtly, it requires distinguishing cases in which each side believes or does not believe the other side believes this. Finally, it requires understanding both sides' perspectives on the balance between relying on deterrence versus preparing for its possible failure. We do not analyze all possible combinations of beliefs; rather we consider illustrative cases. It is noteworthy that the truth about nuclear winter matters only indirectly to the deterrence and crisis management roles of nuclear weapons insofar as the truth affects perceptions of the truth. By contrast, the truth matters directly to the role of warfighting in many scenarios.

It is in the interest of both sides that the other side, but not itself, be concerned with nuclear winter.

Deterrence

Nuclear winter in its more extreme manifestations threatens consequences to the warring parties quite differently from, and possibly even more severe than, the more direct and immediate cataclysmic effects of nuclear weapons. Before publication of the TTAPS study,¹⁰ Departments of Defense and Energy scientists responsible for understanding the effects of nuclear weapons were completely unaware of this phenomenon. The TTAPS authors and their scientist forbears thus deserve great credit for discovering this risk.¹¹

One might deduce that by increasing the consequences of nuclear war, nuclear winter, even in its least-severe manifestations, would serve to enhance deterrence. After all, deterrence ultimately relies on the prospect of unacceptable consequences; the more horrific the consequences, the stronger the deterrent. And as a global phenomenon, both sides and much of the rest of the world will suffer the consequences, so the enhancement to deterrence occurs for all sides. However, it's not as simple as that.

Some leaders, as well as some experts and non-experts alike, are not particularly influenced by nuclear war's increased consequences due to nuclear winter. They argue that nuclear war is already sufficiently horrific that the prospect of nuclear winter, even in the extreme scenarios where billions of additional deaths occur, will have minimal impact on deterrence. At one level, this is, of course, illogical. It matters greatly whether hundreds of millions perish in a nuclear war or billions do. And it's

¹⁰ Turco et al., "Nuclear Winter."

¹¹ An unfortunate side effect of this history was a measure of chagrin created in some government scientists and officials that morphed into resentment and ultimately into skepticism. The situation was not helped by nuclear winter scientists' promotion of unrealistic disarmament policies (Sagan, "Nuclear War and Climatic Catastrophe") and attacks on the morality of deterrence supporters (US General Accounting Office, *Nuclear Winter*; and Robock, "Policy Implications").

worth emphasizing that many of those additional billions would be denizens of countries not party to the conflict. It is morally abhorrent and a violation of international law to threaten or execute such a nuclear strategy because its consequences are grossly disproportionate to any conceivable military objective. At another level, to the extent that military planners subscribe to the idea that nuclear winter should have no effect on deterrence, they make themselves *by definition* correct. As with much of deterrence theory, this is a case of “thinking makes it so” (to paraphrase Shakespeare).

A second phenomenon is at work here as well. If nuclear winter is taken seriously by national leaders, the effect can undermine the will to execute declaratory policy regarding retaliation. Hesitancy to carry out retaliatory threats undermines deterrence. Thus, for example, the perceived (by our adversaries) acceptance (by the United States) of nuclear winter might, perversely, make a nuclear attack against the United States more likely. But this effect is operative only if just one side is influenced by the possibility of triggering a nuclear winter. Thus, it is in the interest of both sides that the other side, but not itself, be concerned with nuclear winter.

To avoid nuclear winter altogether, could deterrence of nuclear attacks be maintained by substituting threats of retaliation using nuclear weapons with threats of other forms of retaliation, such as biological and chemical responses?¹² The answer is no. Many other forms of retaliation (e.g., cyber or chemical warfare) are not sufficiently horrific, while others (e.g., biological warfare) may be sufficiently horrific but are largely uncontrollable, violate international law, and may be even more morally repugnant than nuclear weapons, a clear case of the treatment being worse than the disease. However, at the lowest levels of nuclear first use, it might not always be the best choice to respond with nuclear weapons. An adequate response that

inflicts “unacceptable” damage and sends a sufficiently cautionary message to other adversary nuclear states might be crafted out of a combination of diplomatic, economic, and conventional military means.¹³ Such a response might or might not have net advantages over a nuclear response, however limited.

Warfighting

Nuclear warfighting can take many forms. In particular, nuclear wars may be very limited or unlimited in the employment of available arsenals and in the nature of targeting. For example, tactical nuclear war is often thought of as involving short- to intermediate-range weapons with generally lower yields and limited to a region, such as Europe or South Asia. By contrast, strategic nuclear war is usually thought to involve the arsenals—with their larger yields and longer ranges—of the most powerful nuclear states striking the homelands of each other. These two broad categories encompass a multitude of scenarios and are neither mutually exclusive nor exhaustive; nor should they be considered as marking extremes in the spectrum of possible nuclear wars.

The range of possible nuclear war scenarios creates a corresponding range of possible nuclear winter effects, which might vary from barely perceptible to catastrophic. Many smaller nuclear wars, involving relatively few nuclear weapons, would probably not trigger significant nuclear winter effects. At the same time, any nuclear war, however small its initial phase, has the potential to escalate to ultimately unleash the arsenals of the major nuclear powers and target cities, thereby causing the greatest nuclear winter effects. Thus, only to the extent that one or both sides fear that smaller nuclear wars are likely to lead to large nuclear wars might nuclear winter be a factor in decisions. The prospect of

¹² Baum, “Winter-Safe Deterrence.”

¹³ Hahn and Scouras, *So Many Imperatives, So Little Time*; and Hahn et al., *Minimizing Damage to the Nuclear Taboo*.

nuclear winter would presumably make whichever side (or sides, in multilateral scenarios) took it more seriously more hesitant to engage in any form of nuclear warfighting and less willing to engage in escalatory steps that could lead to a full-scale nuclear winter. Many conceivable nuclear wars lie in the middle with respect to their possible creation of nuclear winter effects. This suggests that even limited efforts to ameliorate nuclear winter effects could have important benefits even if they don't help much in the more extreme scenarios or are unnecessary in the least extreme scenarios.

While, in theory, nuclear warfighting should be influenced by the prospect of nuclear winter, it appears that no nuclear state has modified its warfighting plans to account for it. Possible actions to reduce the consequences of nuclear winter include reducing weapon yields, adjusting burst heights to limit the ignition of fires and lofting of soot and smoke, employing earth-penetrating nuclear warheads where feasible, reducing arsenals available for warfighting, and avoiding the targeting of cities and other sites with large amounts of combustible materials in their vicinities. While some of these actions have been taken, notably reducing weapon yields and arsenals available for warfighting, they are more accurately attributed to improvements in weapon accuracy, arms control, and the end of the Cold War than to concerns about nuclear winter.

Civil defense, taken seriously during portions of the Cold War but eventually abandoned as too costly and insufficiently effective, provides another approach to mitigating the consequences of nuclear winter. Strategies that might be adopted include developing more cold- and low-light-resilient crops, stockpiling food, and planning to utilize resources that might be available from nations expected to fare relatively well in a nuclear winter. Additional research would be necessary to assess the cost and effectiveness of such approaches, as well as their potential applicability to other global catastrophic risk.

More extreme policies intended to prevent the physical possibility of nuclear winter have been proposed, starting with Carl Sagan's call for a "nuclear winter-safe" world. This would require reducing worldwide arsenals to below perhaps a total of some five hundred to two thousand warheads worldwide,¹⁴ compared to the current worldwide arsenals total of about thirteen thousand warheads and the Cold War peak of approximately seventy thousand.¹⁵ It is an understatement to observe that such drastic reductions seem out of reach politically. And, of course, such goals cannot be achieved unilaterally. They would require the cooperation of all nuclear states. Finally, focus on a nuclear winter-safe world might discourage focus on more achievable goals that reduce the more extreme consequences of nuclear winter even if they do not eliminate all such consequences.

Crisis Management

More than a score of nuclear crises arose during the Cold War,¹⁶ and at least five have occurred since the end of that era.¹⁷ From this experience, it's clear that no two nuclear crises are the same. And, thus, there is no one-size-fits-all approach to managing such crises. At one extreme is avoiding nuclear crises in the first place, a policy many nuclear states have tried to follow since they acquired nuclear weapons. At the other extreme lies the tactic of brinkmanship. This involves ratcheting up the risk to the other side of continuing or escalating the crisis. Unfortunately, it generally increases the risk for both sides. The thought is that the side unable to bear the ever-increasing level of risk will capitulate.

¹⁴ Sagan, "Nuclear War and Climatic Catastrophe."

¹⁵ Federation of American Scientists, "Status of World Nuclear Forces" (Estimated Global Nuclear Warhead Inventories 1945–2022 chart); and Sagan, "Nuclear War and Climatic Catastrophe."

¹⁶ Kroenig, "Nuclear Superiority and the Balance of Resolve."

¹⁷ We define nuclear crises as serious international disputes involving two or more nuclear weapons states.

A textbook example is the Cuban missile crisis of 1962.

In the worst-case scenario, billions of additional deaths will occur in the following months and years, the environment will take decades to recover, and civilization will be thrown back centuries. That is the global catastrophic risk we are, by default, accepting by ignoring nuclear winter.

In our view, the possibility of nuclear winter has negligible influence on crisis management. If and when one or more parties to a nuclear crisis take the possibility of nuclear winter seriously, and are motivated to prevent it, avoiding nuclear crises could take on enhanced prominence as a US crisis management approach. By contrast, brinkmanship would entail intentional exposure to even greater risks, thereby making it a less attractive tactic, especially at the higher rungs of the escalation ladder.

As with deterrence, if one side believed the other side was more concerned with the possibility of nuclear winter, it could try to exploit that greater concern by engaging in more reckless forms of nuclear brinkmanship than otherwise. Moreover, all states concerned with nuclear winter—combatant or noncombatant, nuclear capable or nonnuclear—would have a great interest in preventing regional nuclear wars between “minor” nuclear states such as India and Pakistan.

How Does Nuclear Winter Affect Nuclear Risk?

Risk is, in the simplest terms, the potential for harm. It incorporates both the likelihood of a

harmful scenario and the level of its harmful consequences. In our case, the harmful scenario is one in which nuclear winter occurs, which is of course conditioned on the occurrence of nuclear war with all its other attendant horrors. The harmful consequences are all the effects of nuclear winter on humans and other species, the environment, and civilization. To discuss risk, we limit our consideration to cases in which nuclear winter is ignored by both (or all) sides, is feared by both sides, and is ignored by one side but feared by the other side. For the last case, we briefly discuss the side that doesn't fear nuclear winter trying to manipulate the side that fears nuclear winter by using the Cold War history of Soviet attempts in the 1980s to manipulate US nuclear policy.

Nuclear Winter Ignored by Both Sides

If nuclear winter is ignored by both sides, which reflects current reality, the likelihood of nuclear war increases to an unknown, but perhaps minor, degree. However, should nuclear war occur—and if the nuclear winter scientists have been correct in their warnings—in the worst-case scenario, billions of additional deaths will occur in the following months and years, the environment will take decades to recover, and civilization will be thrown back centuries. That is the global catastrophic risk we are, by default, accepting by ignoring nuclear winter. And we are imposing that global catastrophic risk on the entire planet.

Nuclear Winter Feared by Both Sides

If nuclear winter is genuinely feared by both sides, and both sides correctly understand that the other side also fears nuclear winter, it would seem that the risk of nuclear Armageddon would be lowered, also by an unknown degree. In fact, it could be argued that the risk of *any* nuclear war would also be reduced by an uncertain degree, because small nuclear wars can lead to large ones. But perversely,

the common fear of nuclear winter might diminish the perceived likelihood of small nuclear wars escalating to large ones, thereby reducing inhibitions against crossing the nuclear threshold in the first place.

Only One Side Fears Nuclear Winter

The situation is more complicated when only one side fears nuclear winter. Under these conditions, there arises the possibility of the side that doesn't fear nuclear winter trying to manipulate the fear of the other side. There also arise complex interactions involving what one side believes, correctly or incorrectly, the other side believes. To illustrate these interactions, we consider Soviet attempts to manipulate US fears in the late 1980s.

While the official Soviet perspective on nuclear winter was complete and immediate acceptance of the phenomenon as scientifically valid, it is unlikely this reflected their true beliefs. While we cannot say for certain what the Soviets' beliefs truly were, it appears that they either rejected the phenomena, were divided, or were content with remaining willfully ignorant on the subject. Given the large uncertainties in early nuclear winter research, it is unlikely the Soviet government would simply accept nuclear winter as scientifically valid with such apparent ease and readiness. Soviet media and officials claimed that Soviet scientists had independently confirmed the possibility of severe nuclear winter effects; however, it appears the research did not "go beyond the minimum necessary to project an image of concern."¹⁸ Soviet research was criticized by US scientists as derivative of US studies, highly focused on worst-case scenarios, and contributing little to reducing theory uncertainties.¹⁹ More importantly, while there

are many accounts of Soviet government officials publicly stating their acceptance of nuclear winter and chastising those in the West who were skeptical, there is no record they changed or even questioned their own nuclear policy, stockpiles, or strategies.²⁰

Rather than genuinely accepting nuclear winter science, it is more plausible that Soviet officials used nuclear winter as propaganda against the West. Publicly stated Soviet views on nuclear winter were clearly crafted to undermine established US/NATO nuclear policy and the Soviets' broader anti-West agenda. For example, an article published in late 1983 by the Russian News Agency TASS used nuclear winter to criticize the "inhuman aspirations of the US imperialists, who are pushing the world toward nuclear catastrophe."²¹ Western governments' acceptance of the theory would cast doubt on US willingness to use nuclear weapons to defend ourselves and our allies, thus not only weakening central deterrence but also weakening extended deterrence. Moreover, by reaching US audiences with apocalyptic visions, the Soviet Union attempted to weaken public support for US nuclear programs and policies. Such attempts were particularly focused on arguing that the US concept of limited nuclear war would be devastating²² in an attempt to undermine the planned deployment of intermediate-range nuclear delivery systems in Europe as a counter to Soviet deployment of the SS-20 missile.

Nuclear Winter; Weinberger, *Potential Effects of Nuclear War on the Climate*; and Smith, "Soviets Offer Little Help."

²⁰ In 2000, Gorbachev claimed that nuclear winter was "a great stimulus to us, to people of honor and morality, to act in that situation" (Hertsgaard, "Mikhail Gorbachev Explains What's Rotten in Russia"). However, there is little evidence from the late Cold War era that nuclear winter played a role in dramatic reductions to Soviet nuclear arsenals.

²¹ Quoted in Rubinson, "Global Effects of Nuclear Winter."

²² Goure, *Update of Soviet Research*.

¹⁸ Gertler, *Some Policy Implications of Nuclear Winter*.

¹⁹ Director of Central Intelligence, *Soviet Approach to Nuclear Winter; Nuclear Winter and Its Implications, Hearings*; Goure, *Update of Soviet Research*; Gertler, *Some Policy Implications of*

We advocate that the United States establish a program of policy analysis focused on striking a reasonable balance between ameliorating the worst consequences of nuclear winter and maintaining effective deterrence, warfighting, and crisis management strategies.

Final Thoughts

Nuclear winter is a global catastrophic risk with potentially extreme consequences beyond those posed by the more immediate and direct effects of nuclear war. The risk of nuclear winter can be decreased by *reducing* its (worst) consequences or by *preventing* nuclear war in the first place. The United States, as well as all other nuclear states, has chosen to put all its eggs in the prevention basket, intentionally ignoring the possibility of nuclear winter.

Our analysis reveals two primary reasons for this approach. First, there is only so much any single nuclear state can do by itself to reduce nuclear winter's consequences. Considering the history of Soviet attempts at manipulating US nuclear policy by exploiting fears of nuclear winter, cooperation of all major nuclear powers seems highly unlikely. The most effective options are to greatly reduce the largest nuclear arsenals and modify targeting doctrine to exclude cities from target lists. However, both of these options require formal or at least tacit international cooperation far beyond what appears plausible or prudent in the foreseeable future and are generally unverifiable. Additionally, the risk of nuclear winter could be reduced if we developed nuclear and, especially, nonnuclear retaliation options intended to increase the likelihood of keeping limited nuclear use *limited*.

The second, and largely unspoken, reason for focusing solely on preventing nuclear war is that the side believed to be more concerned about the risk of nuclear winter is at a disadvantage in nuclear deterrence, warfighting, and crisis management. Although the magnitude of this effect is highly uncertain, the greater the difference in concerns, the greater the disadvantage. We believe these two reasons go a long way to explaining the indifference the United States has toward nuclear winter.

We also believe it is time to revisit this approach. Notwithstanding a “nuclear peace” that has lasted over three-quarters of a century, as the brandishing of nuclear weapons over the war in Ukraine so amply demonstrates, we have not slain the nuclear dragon. And after a period of optimism in the aftermath of the end of the Cold War, we are now facing a future of increasing nuclear risks as more states acquire nuclear capabilities and international disputes endure. Thus, it would be prudent to more carefully consider the possibility of the failure of nuclear deterrence. Among the first issues to address is the prospect of nuclear winter. As discussed in greater detail in our companion paper,²³ we advocate that the United States establish a comprehensive scientific program to resolve major scientific uncertainties, with a concomitant program of policy analysis focused on striking a reasonable balance between ameliorating the worst consequences of nuclear winter and maintaining effective deterrence, warfighting, and crisis management strategies.

²³ Proper, Ice, and Scouras, *Whatever Happened to Nuclear Winter?*

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Acknowledgments

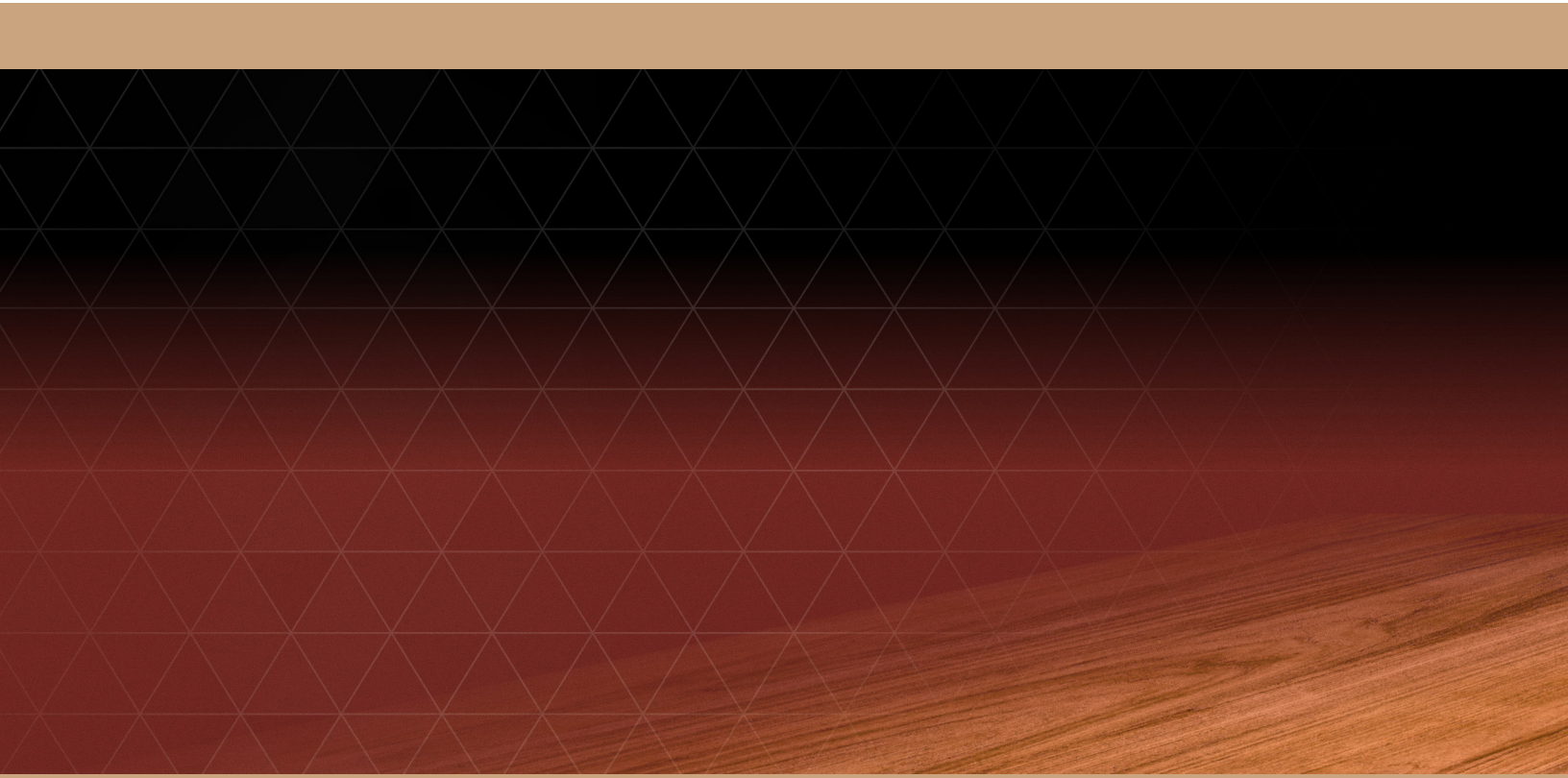
We thank Bilal Ayyub, Dennis Evans, Martin Hellman, Christian Ruhl, Matthew Schaffer, and Kerstin Vignard for their thoughtful reviews of earlier drafts of this essay.

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