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Confronting the Pandemic Superthreat of Climate Change and Urbanization

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Abstract: One of the most devastating shocks to global security imaginable is a pandemic. As history helps to demonstrate, this catastrophe and its reverberations could in today's world create a scene not unlike that depicted in the Book of Revelation, when the pale horse and its rider Death sow destruction "with sword and with famine and with pestilence." To protect our own interests and security, it is imperative that the United States take preventive actions against a potential pandemic. This article argues that one important area for mitigation is climate change interacting with the growing urbanization of the world's population. These two factors combined promise massive shocks to global security, and because of the destructive potential, it is critical that U.S. national-security professionals consider this worst-case future when developing policies and strategies. If a large-scale pandemic does occur, as many scientists believe possible, are we prepared to handle it? Have we taken the actions necessary to mitigate the worst-case outcome? This article also argues that a lead actor in prevention efforts should be the U.S. military, which has the reach and resources that others do not.

Biological threats—whether naturally occurring, accidental, or deliberate in origin—are among the most serious threats facing the United States and the international community.

- The United States National Biodefense Strategy¹

The bane of stable international systems is their near total inability to envision mortal challenge.

- Henry Kissinger²

¹ The President of the United States, *National Biodefense Strategy* (Washington, DC, 2018), p. i, <https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Biodefense-Strategy.pdf>.

² Henry Kissinger, *Diplomacy* (New York: Simon and Schuster, 1994), p. 133.

The grand illusion. . . is that the collectivity of states is capable of agreeing upon the taking of decisive action.

- Colin S. Gray³

Much has been written about climate change and its causes and effects. While some deny that climate change is happening or that humans have any mitigating role to play,⁴ most reasonable people would concede that climate change poses real problems that must be addressed.⁵ Regardless of one's skepticism on the matter of climate change, it is essential to consider its worst-case outcomes when developing U.S. security strategies and policies. As the Department of Defense (DoD) has reported to Congress, "The effects of a changing climate are a national security issue with potential impacts to [DoD] missions, operational plans, and installations."⁶ Of the projected negative effects of climate change, from severer storms to more extensive droughts, probably the threat with the most devastating potential is a pandemic. From disrupting trade to decimating populations, a pandemic could potentially cause more destruction than a nuclear strike;⁷ thus, it is essential to understand how changing climate could unleash such destruction—with little to no advance warning—and how we can best manage the consequences.

Most experts agree that the world is heading into a potentially severe warming phase, with average temperatures expected to rise 2-6 degrees Celsius (C) by the end of this century.⁸ As a result, weather events such as heat waves and storms, and the attendant consequences of droughts and floods, are expected to increase in frequency

³ Colin S. Gray, *Fighting Talk: Forty Maxims on War, Peace, and Strategy* (Lincoln: Potomac Books, 2009), p. 23.

⁴ Sallie Baliunas, "Warming Up to the Truth: The Real Story About Climate Change," *The Heritage Foundation*, Aug 22, 2002, <https://www.heritage.org/environment/report/warming-the-truth-the-real-story-about-climate-change>; and Jason Taylor, "'Global Warming the greatest scam in history' claims founder of Weather Channel," *Express*, June 9, 2015, <https://www.express.co.uk/news/clarifications-corrections/526191/Climate-change-is-a-lie-global-warming-not-real-claims-weather-channel-founder>.

⁵ Richard Wike, "What the world thinks about climate change in 7 charts," *Pew Research Center*, April 18, 2016, <http://www.pewresearch.org/fact-tank/2016/04/18/what-the-world-thinks-about-climate-change-in-7-charts/>.

⁶ Office of the Under Secretary of Defense for Acquisition and Sustainment, "Report on Effects of a Changing Climate to the Department of Defense," Jan. 2019, https://climateandsecurity.files.wordpress.com/2019/01/sec_335_ndaa-report_effects_of_a_changing_climate_to_dod.pdf. This report mentions "disease mitigation," but only in the broadest terms.

⁷ Colin S. Gray, *Another Bloody Century: Future Warfare* (London: Weidenfeld & Nicolson, 2005), p. 287. Gray argues that "biological weapons could in theory wreak more havoc than the nuclear arsenal of any regional power, let alone any nuclear capability likely to be cobbled together by terrorists."

⁸ Emily K. Shuman, M.D., "Global Climate Change and Infectious Diseases," *The New England Journal of Medicine*, vol. 362, no. 12 (March 25, 2010), p. 1061. This equates to 3.6-10.8 degrees Fahrenheit.

and severity.⁹ And due to these climatic and weather changes, a significant increase is expected in the potential for infectious diseases transmitted via insects, rodents, and contaminated water.¹⁰ Deadly diseases carried by insects, such as malaria, thrive at higher temperatures and so are expected to be a more active threat in the years ahead. In addition, waterborne infectious diseases, such as cholera, will also likely increase due to poor sanitation caused by water scarcity in times of drought and by “overwhelmed sewage lines or the contamination of water by livestock” during times of flooding.¹¹ As an example of how bad a cholera epidemic can become, consider the recent outbreak in Yemen, which erupted in April 2017 and has since led to over one million suspected cases and over 2,500 deaths.¹² The ongoing civil war in Yemen and the resulting scarcity of water have exacerbated the epidemic.¹³

A Deadly History

Pandemic disasters caused by climate change are not new; there are plenty of examples in world history. One especially tragic example is the “Black Death” of the mid-fourteenth century, which killed upwards of 75 million people in Europe and Asia and likely was caused by climatic changes that stimulated the growth of the rodent population. Certainly, this example involved a complex interaction of factors over an extended period of decades. A mild climate in eastern Kazakhstan and southwest China “fostered plant-food abundance and hence wild rodent proliferation.” As a subsequent cooling took place, “plant growth declined” and catastrophic floods “displaced and drowned many people.” The environmental changes “likely also displaced wild rodents and increased rodent-human contact.” At the same time, in western China “encroaching nomadic Mongol pastoralists” and “Han Chinese farmers” engaged in increased conflict, and this also displaced people and likely increased rodent-human contact. This chain of climatic effects could well have potentiated a deadly plague epidemic. “Before long, trade caravans or (more probably) horse-borne Mongol armies, with ‘companion’ black rats, carried the disease westward

⁹ Shuman, “Global Climate Change and Infectious Diseases.”

¹⁰ Shuman, “Global Climate Change and Infectious Diseases.” See, also, Bradley A. Thayer, *Darwin and International Relations* (Lexington: The University Press of Kentucky, 2004), p. 197.

¹¹ Shuman, “Global Climate Change and Infectious Diseases,” p. 1062.

¹² Stephanie Nebhay, “Yemen cholera outbreak accelerates to 10,000+ cases per week: WHO,” *Reuters*, Oct. 2, 2018, <https://www.reuters.com/article/us-yemen-security-cholera/yemen-cholera-outbreak-accelerates-to-10000-cases-per-week-who-idUSKCN1MC23J>.

¹³ Megan O’Toole, “What is fuelling [sic] Yemen’s cholera epidemic?” *Al Jazeera*, September 5, 2017, <https://www.aljazeera.com/indepth/features/2017/09/fuelling-yemen-cholera-epidemic-170905090641210.html>.

into Europe . . . via the Black Sea port of Kaffa.” Within ten years, Europe’s population was decimated.¹⁴

This pandemic starkly illustrates the dark side of fourteenth-century globalization. It demonstrates all too clearly that climate changes in one location can result in cascading effects that ripple around the world and eventually wreak havoc far removed from the source of initial disaster. Those forces were the same ones that we face today: natural disasters, migrations of people, conflict over scarce resources, and ultimately a pandemic transmitted around the world through trade and war. At present, with billions more people and modern means of transportation, it is clear the same situation today would be exponentially more disastrous. Lest one think that modern society is safer due to advanced technology and capabilities, consider that many experts believe the opposite: modern societies, though better resourced and more interconnected, are also more densely populated and infrastructure-dependent, and hence less flexible and more vulnerable to a sudden disastrous shock.¹⁵

An Explosive Combination

One of the starkest differences between now and the mid-fourteenth century is how populated the earth is at present, and how much of that population has crowded itself into urban centers. The current world population is over 7.5 billion people, approximately 55 percent of whom live in urban environments.¹⁶ Compare that to a world population of approximately 450 million before the onset of the “Black Death,” most of whom lived in rural, sparsely populated areas.¹⁷ Looking ahead, the trend to urbanization is only expected to continue: experts estimate that roughly 68 percent of the population will live in dense urban environments by the year 2050.¹⁸

While the movement of rural populations to cities is caused by several factors, including economic and educational opportunities, it is being exacerbated by the increased incidence of droughts, floods, and other consequences associated with climate change.¹⁹ These climate-related disasters hurt agricultural production and serve as “push” factors from rural to urban, just as jobs and education serve as “pull” factors. Experts predict that climate-induced migrations potentially will accelerate after 2050.²⁰

¹⁴ Anthony J. McMichael, “Insights from past millennia into climatic impacts on human health and survival,” *PNAS* 109, no. 13 (March 27, 2012), pp. 4 and 734, <https://www.pnas.org/content/109/13/4730>.

¹⁵ McMichael, “Insights from past millennia into climatic impacts on human health and survival,” pp. 4 and 730.

¹⁶ The World Bank, Population Tables, <https://data.worldbank.org/indicator/SP.POP.TOTL> and <https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS>.

¹⁷ The United States Census Bureau, Historical Estimates of World Population, <https://www.census.gov/data/tables/time-series/demo/international-programs/historical-est-worldpop.html>.

¹⁸ UN, Department of Economic and Social Affairs, May 16, 2018, <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>.

¹⁹ IOM, United Nations, <https://www.iom.int/migration-and-climate-change-0>.

²⁰ IOM.

Most of the urban growth is projected to occur in Asia and Africa, where developing countries dominate the landscape²¹ and where basic healthcare, sanitation, and other infrastructure is sorely lacking in rural areas.²² As a result, cities in developing countries that are already at, or near, the limits of the population they can adequately support are being slowly overwhelmed by at-risk migrants who are overtaxing already weak infrastructure and security systems. This problem is exacerbated by the rapid development of megacities, defined as having a population in excess of 10 million. “In 2017, developing nations boasted 26 megacities compared to seven in developed countries.”²³ This trend toward expansion in developing countries is set to continue, especially in Africa. For example, Luanda, predicted to become a megacity by 2030, “is expected to undergo a 60 percent increase in its population between 2017 and 2030, placing further strain on housing, transport, public utilities and sanitation.”²⁴

One critical problem with the expanding urban landscape is that the growth is largely uncoordinated. Densely populated shanty towns and slums ring the edges of otherwise modern and ordered square blocks of skyscrapers and malls.²⁵ The uncontrolled development leads to increased human interaction with rats and other rodents, thereby greatly increasing the likelihood of zoonotic infectious diseases.²⁶ Also increasing the potential for zoonotic contagions is that the new populations push cities out into previously undisturbed ecosystems (e.g., adjacent deserts and forests), and as a result contact between animals and humans increases, generally in unsanitary environments.²⁷ The overcrowded conditions heighten the risk of vector-borne diseases, such as malaria and dengue fever.²⁸ Basic sanitation and water systems become overwhelmed, resulting in contaminated water supplies and increasing the

²¹ IOM.

²² World Bank, “Groundswell: Preparing for Internal Climate Migration,” p. xix.

²³ Johnny Wood, “Here’s what you need to know about the megacities of the future,” *World Economic Forum*, Oct. 10, 2018, <https://www.weforum.org/agenda/2018/10/these-are-the-megacities-of-the-future/>.

²⁴ Wood, “Here’s what you need to know about the megacities of the future.”

²⁵ Raquel Reyes, Roy Ahn, Katherine Thurber, and Thomas F. Burke, “Urbanization and Infectious Diseases: General Principles, Historical Perspectives, and Contemporary Challenges,” in I. W. Fong, ed., *Challenges in Infectious Diseases* (New York: Springer Science+Business Media, 2013), p. 125.

²⁶ Carl-Johan Neiderud, M.D., “How urbanization affects the epidemiology or emerging infectious diseases,” *Infection Ecology and Epidemiology* (2015), p. 4; and Reyes et al., “Urbanization and Infectious Diseases,” p. 129.

²⁷ Reyes et al., “Urbanization and Infectious Diseases,” p. 133. See, also, Thayer, *Darwin and International Relations*, p. 198. “Suburban sprawl into previously unpopulated areas is also a significant cause of new interaction between humans and other species.”

²⁸ Neiderud, “How urbanization affects the epidemiology or emerging infectious diseases,” p. 3; Reyes et al., “Urbanization and Infectious Diseases: General Principles, Historical Perspectives, and Contemporary Challenges,” p. 133; see, also, Thayer, *Darwin and International Relations*, p.198. “Climate change forces more birds and mosquitoes into places well populated by humans, and these animals bring new microbes into contact with people.”

potential for cholera and other water-borne diseases.²⁹ Diseases that were formerly confined to rural areas accompany the migrants into the new urban environment, where they have a much greater chance to thrive.³⁰ Security services are often unable to properly police the expanded slum areas, which can become lawless and less secure. In addition, where order has disappeared, other city services generally will not go. Most critically, existing healthcare services cannot properly serve the increased population. If a pandemic takes root in such an environment, chances are high that it will spread rapidly before it can be detected.

To understand how severe the problem can become, one can look at Mogadishu, Somalia. Mogadishu's devastation has been caused by many factors, including poverty, violence, and lack of effective governance.³¹ Climate change has been a significant contributor to all of this. As scholars Giovanna Kuele and Ana Cristina Miola have noted, "Over the past decade climate change-related desertification has expanded in Somalia, greatly increasing the vulnerability of the local population."³² This change has sharpened disputes over scarce water resources and has led to "high rates of malnutrition, disease outbreaks, and food insecurity." Cholera epidemics have been recurrent in Somalia, the most recent one starting in late 2017, and thousands have died as a result.³³ With disease and violence rampant, over one million Somalis have been displaced; with Mogadishu in utter chaos, many of them have migrated to nearby Kenya, thus putting a strain on Kenya's resources.³⁴ In the Yemen cholera outbreak noted above, scientists have determined that the strain causing the outbreak "came from Eastern Africa and entered Yemen with the migration of people in and out of the region."³⁵ Thus, it is likely that Somalia's dysfunction has contributed to Yemen's. Combined, these problems have enabled easier recruitment of warlords,

²⁹ Reyes et al., "Urbanization and Infectious Diseases," p. 132.

³⁰ Reyes et al., "Urbanization and Infectious Diseases," p. 127.

³¹ Halae Fuller, "Climate Change and Famine in Somalia," *Stimson*, Aug. 9, 2011, <https://www.stimson.org/content/climate-change-and-famine-somalia>.

³² Giovanna Kuele and Ana Cristina Miola, "Somalia: the Role of Climate Change in Recurring Violence," *Igarape Institute*, Nov. 6, 2017, <https://igarape.org.br/en/somalia/>.

³³ Consider the following: "After nearly three decades of continuous conflict, Somalia has a barely existent government with no public health system and 800,000 people driven into unsanitary settlements by drought and insecurity—perfect conditions for cholera to thrive." "This [2017 outbreak] is Somalia's worst cholera outbreak in five years. So far, 71,663 cases have been counted, including more than 1,098 deaths." "In 2011, drought led to a famine in which 250,000 people died from hunger and related diseases, including cholera." Amanda Sperber, "Somalia's impossible fight against cholera," *IRIN*, Aug. 1, 2017,

<https://www.irinnews.org/feature/2017/08/01/somalia-s-impossible-fight-against-cholera>. See, also, World Health Organization, "Cholera – Somalia," *World Health Organization*, March 29, 2018, <https://www.who.int/csr/don/29-march-2018-cholera-somalia/en/>.

³⁴ "Around 300,000 Somalis [sic] refugees living in the Dabaab refugee complex—the world's largest refugee camp, located in neighboring Kenya—have faced heightened uncertainty since Kenya announced that the compound would close." Kuele and Miola, "Somalia: the Role of Climate Change in Recurring Violence."

³⁵ "Mystery of Yemen cholera epidemic solved," *Science Daily*, Jan. 2, 2019, <https://www.sciencedaily.com/releases/2019/01/190102140745.htm>.

intent on controlling the capital city Mogadishu through violence and terror.³⁶ Mogadishu is the prime example of what Richard J. Norton has termed “feral cities,”³⁷ where degradation and insecurity create conditions where disease and violence flourish.

An Aggressive Offense

Be Realistic. More aggressive action is required to resolve, or at least mitigate, the immediate consequences and near-horizon disasters looming as a result of climate change and increasing urbanization—especially regarding the possibility of a pandemic.³⁸ Several arms of the U.S. government, including the Department of State (DoS), the U.S. Agency for International Development (USAID), and the Centers for Disease Control and Prevention (CDC), are actively combatting disease and climate change around the world. However, none of these agencies can match the global presence³⁹ and financial heft of DoD. This realization is especially true in the current political environment, as the Trump administration seems intent on cutting foreign assistance and health budgets while increasing DoD’s. For example, President Trump’s FY 2020 Budget “requests \$718 billion for DOD, a \$33 billion or five-percent increase from the 2019 enacted level”; at the same time, it “requests \$40.0 billion for the Department of State and USAID, a \$12.3 billion or 23-percent decrease from the 2019 estimate.”⁴⁰ Congress is unlikely to agree with the president’s overall budget proposal, now or in the future, but it seems safe to predict that military resources will increase. Due to its global reach and resources, the U.S. military is better placed than

³⁶ “The relationship between the proliferation of illegal armed groups and the severe droughts in Somalia is evident in the case of al-Shabaab. The group has been successful in attracting young people who are affected by famine and food insecurity and who face no job prospects; those youth end up joining the armed group in a bid to survive, finding no other option other than to submit to the extremist group.” Kuele and Miola, “Somalia: the Role of Climate Change in Recurring Violence.”

³⁷ Richard J. Norton, “Feral Cities,” *Naval War College Review*, LVI, no. 4 (Autumn 2003), p. 97.

³⁸ For an example of what can happen when an organization focuses too much on long-term political solutions and too little on near-term mitigating actions, see, Russell Gold, “PG&E: The First Climate-Change Bankruptcy, Probably Not the Last,” *Wall Street Journal*, Jan.18, 2019, <https://www.wsj.com/articles/pg-e-wildfires-and-the-first-climate-change-bankruptcy-11547820006>.

³⁹ In addition to staffing nearly every U.S. embassy, the American military has bases at key locations around the globe. No other agency can match this presence or the type of relationships that the military fosters. For an unclassified list of U.S. military bases around the world, see, Military.com, <https://www.military.com/base-guide/browse-by-location>.

⁴⁰ The President of the United States, *A Budget for a Better America: Fiscal Year 2020 Budget of the U.S. Government* (Washington, D.C., 2019), pp. 23 and 71, <https://www.whitehouse.gov/wp-content/uploads/2019/03/budget-fy2020.pdf>. See, also, Kate Davidson, “White House Proposes \$4.7 Trillion for Fiscal 2020,” *Wall Street Journal*, March 11, 2019, https://www.wsj.com/articles/white-house-proposes-4-7-trillion-budget-for-fiscal-2020-11552319265?mod=hp_lead_pos1.

nearly any other organization and should take an aggressive leading role in preventive efforts.

Unfortunately, to date, the international community has not demonstrated the will to act decisively on climate change. While many nations voluntarily have signed onto international agreements, such as the Kyoto Protocol and the Paris Agreement, few of these countries adhere to the agreed standards.⁴¹ And, the agreed standards themselves have been called into question as not being sufficient.⁴² In addition, some of the greatest contributors to pollution and environmental degradation flagrantly ignore climate concerns.⁴³ Indeed, both India and China, two of the biggest polluters in the world, were exempted from the Kyoto Protocol, and the Paris Agreement contains no formal enforcement mechanisms—one of the glaring weaknesses of internationally engineered solutions to climate change.⁴⁴ At the recent climate gathering in Katowice, Poland, participants agreed to a new rulebook to improve the Paris Agreement; however, details of the “rulebook” are not clear, and key countries did not support the creation of a global carbon market, seen by many economists as the key to reducing carbon emissions worldwide.⁴⁵ The gathering appeared to promise more of the same: heavy polluters will continue to pollute, while certain developed countries will continue voluntarily to reduce emissions (or not).⁴⁶

This is not to say that international government organizations (IGOs) bring no benefit to the discussion. The United Nations and other IGOs serve a useful role in raising awareness, providing a forum for debate, and providing resources in some

⁴¹ David G. Victor, Keigo Akimoto, Yoichi Kaya, Mitsutsune Yamaguchi, Danny Cullenward, and Cameron Hepburn, “Prove Paris was more than paper promises,” *Nature*, Aug. 1, 2017, <https://www.nature.com/news/prove-paris-was-more-than-paper-promises-1.22378>.

⁴² Fiona Harvey, “World on track for 3C of warming under current global climate pledges, warns UN,” *The Guardian*, Nov. 3, 2016, <https://www.theguardian.com/environment/2016/nov/03/world-on-track-for-3c-of-warming-under-current-global-climate-pledges-warns-un>.

⁴³ James Delingpole, “United States and China Snub United Nations Climate Talks,” *Climate Change Dispatch*, Dec. 5, 2018, <https://climatechangedispatch.com/us-china-snub-climate-talks/>.

⁴⁴ Oliver Milman, “James Hansen, father of climate change awareness, calls Paris talks ‘a fraud,’” *Guardian*, Dec. 12, 2015, <https://www.theguardian.com/environment/2015/dec/12/james-hansen-climate-change-paris-talks-fraud>.

⁴⁵ Emre Peker, “Climate Negotiators Agree on Rulebook to Help Curb Emissions,” *Wall Street Journal*, Dec. 15, 2018, <https://www.wsj.com/articles/negotiators-agree-on-rulebook-to-help-curb-climate-change-11544928096>.

⁴⁶ Though some countries claim to be reducing carbon emissions voluntarily, data exists to show that some of these claims are bogus. Germany, for example, has likely been at the same level of emissions since 2009, even though it has spent \$181 billion on solar and wind technology in the past five years. See, Holman W. Jenkins, Jr., “Will 2019 See Climate Maturity?” *Wall Street Journal*, Dec. 24, 2018, https://www.wsj.com/articles/will-2019-see-climate-maturity-11545690197?emailToken=49c49f5daa6c4fccc04a537dad514c4fPACFeu2090Ds2swjiZp/9tIq+m2q1Hge5f6cBHgtyRto+IDdlauCMI.DM7niyxET Y53MQfAXBrcFLev5mOdJgPQ%3D%3D&reflink=article_email_share.

cases.⁴⁷ For these reasons alone, the United States should stay actively involved in international efforts to combat climate change and ensure as much as possible that U.S. interests are promoted. However, a realist understands that due to the inefficiencies of international consensus-building, IGOs' actions generally will be longer-term solutions with slow and clumsy implementation.⁴⁸ As Divya Srikanth has written: "Developed states are highly reluctant to voluntarily stunt their economic growth by adhering to the Kyoto Protocol, and developing states are unwilling to compromise on their new-found economic successes. This has led to a stalemate in terms of tackling the impact of climate change."⁴⁹ Though the stalemate shows no positive signs of breaking, due to the severity of the stakes involved, America cannot abdicate leadership in this long-term effort. At the same time, it must lead efforts to combat the near-term consequences of climate change.

Engage Partners, Including China. Fighting pandemics is one issue on which nations should share strategic goals and could therefore use the opportunity to build better relations.⁵⁰ The United States should utilize this common interest and leverage alliances and partnerships in the most at-risk locations.⁵¹ For example, one of the current hotspots for a future pandemic to break-out is Southeast Asia, specifically the Sulu-Sulawesi Sea area. The U.S. military currently works closely with Indonesia, Malaysia, and the Philippines—the countries that ring the Sulu-Sulawesi Sea—on counterterrorism and anti-piracy actions in the area. These relationships could be leveraged to take additional actions to prevent a pandemic from breaking out there, such as increased coordination and construction of research, detection, and healthcare facilities along the sea's edge.⁵² Even China, which has a significant interest in the

⁴⁷ Thomas G. Weiss, "The United Nations: Before, During and After 1945," *International Affairs*, vol. 91, no. 6 (Nov. 2015), pp. 1227-1230. Weiss discusses the concept of a "third UN," consisting of "non-governmental organizations (NGOs), external experts, scholars, consultants, transnational corporations (TNCs), the media and committed citizens who work closely with the UN's intergovernmental machinery and secretariats."

⁴⁸ For a good discussion on the ineffectiveness of international institutions, see, Gray, *Fighting Talk*, pp. 20-23.

⁴⁹ Divya Srikanth, "Non-Traditional Security Threats in the 21st Century: A Review," *International Journal of Development and Conflict*, vol. 4 (2014), p. 67.

⁵⁰ Chad Michael Briggs, "Climate security, risk, assessment and military planning," *International Affairs*, vol. 88, no. 5 (Sept. 2012), p. 1,063.

⁵¹ James Cook argues: "One way to achieve greater flexibility is to refocus and adapt standing alliances to address contemporary security challenges," James L. Cook, "Military Alliances in the 21st Century: Still Relevant after all These Years?" *Orbis*, vol. 57, no. 4 (Autumn 2013), p. 571.

⁵² For a full argument on why the Sulu-Sulawesi Sea is a likely epicenter for a pandemic, and on how the United States works closely with other countries in the region, see, Kenneth L. Meyer, "Nature and Terror in the Sulu-Sulawesi Sea: Stopping the Next Pandemic" (research paper for Joint Military Operations seminar, Naval War College, 2018).

Sulu-Sulawesi Sea and the adjacent South China Sea,⁵³ could be pulled into a multilateral partnership to fight against a pandemic.

There are multiple challenges to a U.S.-China partnership, including lack of trust and a competition for influence, especially in Southeast Asia. As author Robert Kaplan recently wrote, U.S-China differences are “stark and fundamental” and “can barely be managed by negotiations and can never really be assuaged.”⁵⁴ However, there are opportunities to exploit, one of which is China’s experience dealing with its own deadly disease outbreak in 2002-2004, when Severe Acute Respiratory Syndrome (SARS) took root in Guangdong province and eventually infected over 8,000 people and killed more than 900.⁵⁵ According to one Chinese public health official, “The SARS crisis provided an enormous boost to the development of China’s public health system.”⁵⁶ China is also considered by some to be a likely origin of a future pandemic, especially from H7N9 bird flu, which Chinese and Western scientists have been studying closely in hopes of preventing a disastrous spread.⁵⁷ Presumably, China has significant knowledge and resources to contribute in the war against pandemics. China also is keen to build roads, ports, and other facilities as part of its Belt and Road Initiative (BRI),⁵⁸ especially in developing regions such as Africa, and it has significant experience managing the growth of megacities.⁵⁹ Through effective partnering, China’s infrastructure investments and its planning experience could be harnessed toward mitigating the negative consequences of climate change and urbanization.

To consider an indirect approach, China is realizing that its rapidly aging population will not accommodate the country’s current plan of sustained economic

⁵³ China is Indonesia’s number one trading partner, importing significant amounts of coal, rubber, and oil every year, much of which transits the Sulu-Sulawesi Sea. Daniel Workman, “Indonesia’s Top Trading Partners,” *World’s Top Exports*, Sept. 30, 2018, <http://www.worldstopexports.com/indonesias-top-15-import-partners/>.

⁵⁴ Robert D. Kapan, “A New Cold War Has Begun,” *Foreign Policy*, Jan. 7, 2019, <https://foreignpolicy.com/2019/01/07/a-new-cold-war-has-begun/>.

⁵⁵ Zhuang Pinghui, “How the SARS outbreak changed mainland China,” *South China Morning Post*, Feb. 20, 2013, <https://www.scmp.com/news/china/article/1154190/how-sars-outbreak-changed-mainland-china>. For infection and death figures, see, Anmar Frangoul, “Counting the cost of a global epidemic,” *CNBC*, Feb. 6, 2014, <https://www.cnbc.com/2014/02/05/counting-the-costs-of-a-global-epidemic.html>.

⁵⁶ Pinghui, “How the SARS outbreak changed mainland China.”

⁵⁷ Melinda Liu, “Is China Ground Zero for a Future Pandemic?” *Smithsonian.com*, Nov. 2017, <https://www.smithsonianmag.com/science-nature/china-ground-zero-future-pandemic-180965213/>.

⁵⁸ BRI is also referred to as the One Belt, One Road (OBOR) Initiative. For a brief overview, see, Bradley A. Thayer and John M. Friend, *How China Sees the World: Han-Centrism and the Balance of Power in International Politics* (Lincoln: Potomac Books, 2018), pp. 89-92. For a good discussion of China’s efforts in Africa, see, Eleanor Albert, “China in Africa,” *Council on Foreign Relations*, July 12, 2017, <https://www.cfr.org/backgrounder/china-africa>.

⁵⁹ China has six megacities. One of them is its showcase city, Shanghai, with a population of 24.5 million. See, Sharon Omondi, “What Is A Megacity?” *World Atlas*, last updated June 28, 2018, <https://www.worldatlas.com/articles/what-is-a-megacity.html>.

growth as a means to sustain internal stability and increase global influence.⁶⁰ As China envisions negative population growth as early as 2030,⁶¹ it will need to partner creatively with other countries and organizations to attain the necessary prosperity to support its changed demographics.⁶² The United States should leverage China's changing domestic politics to pull it into constructive partnerships on health and climate-change (and other) matters, and thereby, it is hoped, increase its stake in an international rules-based order. This becomes especially important as China seeks to build-up its navy and spread its influence. As Bernard-Henri Levy has written, "One may hope, though without illusions, that China will send its steel junks in the wake of the fleets of the wise Zheng He, China's admiral of the western seas and leader of expeditions *bound for glory and not for conquest*."⁶³ Active and constructive engagement on human-security problems is one way to help make this happen.

Research and Model. One of the most effective defenses against a future pandemic is to undertake research now in the hopes of discovering the potential pandemic before it discovers us. Several governments and NGOs are actively engaged in this type of research; however, they often lack adequate resources or cohesion to be truly effective.⁶⁴ The U.S. military could fill a serious need by bringing its resources to bear. The Naval Medical Research Unit (NAMRU) is an entity that the military could employ to establish laboratory facilities to conduct research and support that of others, and to help develop and maintain an organized database of useful information.⁶⁵ USAID's Emerging Pandemic Threats program is one effort that this unit could support more deeply,⁶⁶ and an example of an effective component of this program is

⁶⁰ "In China, an Unprecedented Demographic Problem Takes Shape," *Stratfor*, Jan. 4, 2019, <https://worldview.stratfor.com/article/china-unprecedented-demographic-problem-takes-shape#/home/error>.

⁶¹ "In China, an Unprecedented Demographic Problem Takes Shape."

⁶² Bearing this out, in early March 2019, China lowered its 2019 economic growth target "to between 6% and 6.5%, bowing to a deepening slowdown that can't be quickly arrested without aggravating already-high debt levels." Liyan Qi and Grace Zhu, "Chinese Exports Plunge as Slowdown Deepens," *Wall Street Journal*, March 8, 2019, <https://www.wsj.com/articles/chinese-exports-slump-as-slowdown-deepens-11552027014?mod=searchresults&page=1&pos=12>.

⁶³ Bernard-Henri Levy, *The Empire and the Five Kings: America's Abdication and the Fate of the World* (New York: Henry Holt, 2019), p. 245. Emphasis added.

⁶⁴ Effective cohesion is a significant challenge. Many governments of developing countries do not have the capabilities to organize effective response efforts, and IGOs, USAID, and others often do not have sufficient resources.

⁶⁵ "Review of the DoD-GEIS Influenza Programs: Strengthening Global Surveillance and Response," Committee for the Assessment of DoD-GEIS Influenza Surveillance and Response Programs, Board on Global Health, Institute of Medicine, and Committee for the Assessment of DoD-GEIS Influenza Surveillance and Response Programs, Washington, D.C.: National Academies Press, 2007.

⁶⁶ USAID, Emerging Pandemic Threats, <https://www.usaid.gov/news-information/factsheets/emerging-pandemic-threats-program>.

the PREDICT project, based at the University of California, Davis.⁶⁷ These organizations and others are researching contagions that potentially could infect humans, especially from animal hosts, and possible vaccines to combat them. Researchers perform their work in areas where contagions are most likely to take root, such as the Sulu-Sulawesi Sea described above. It is areas like this where the U.S. military should concentrate its efforts.

As part of its research, the U.S. military can engage in predictive modeling, trying to determine based on weather patterns, people movements, socioeconomic factors, and potential contagions—what this author collectively refers to as *pandemic intelligence*—where the next pandemic might break out. An effective partner would be the National Oceanic and Atmospheric Administration (NOAA), which has programs and technology in place to monitor weather patterns and climate activity.⁶⁸ The military could harness NOAA’s capabilities and knowledge, and that of others, to consider the potential cascade effects that would occur should a pandemic take root and spread. As Chad Michael Briggs has noted, “Environmental systems often exhibit feedback and multiplier effects, where a smaller change in one area leads to a cascade of impacts with much greater shifts elsewhere.”⁶⁹ For example, a 2010 heatwave in Russia caused a food shortage and price spikes in North Africa and the Middle East and thus likely contributed to the Arab Spring revolts.⁷⁰ Cascade predictions could help to predict both near- and long-term consequences and would thus be critical in ensuring up-to-date Operational Plans to be used by the military when responding to pandemic outbreaks, and for efforts to prevent or contain outbreaks when responding to natural disasters.

Surveil and Detect. It is also critical to conduct surveillance of possible threats from weather events, sudden migrations of people, and detected contagions.⁷¹ Many developing countries lack modern and reliable warning systems for incoming severe storms. One of the reasons more than 1,200 people died when a tsunami hit Sulawesi, Indonesia, in September 2018, was that the populations in its path were not properly forewarned of the seriousness of the danger.⁷² The U.S. military should help to ensure that essential warning systems are in place at critical spots, especially in Southeast

⁶⁷ University of California, Davis, PREDICT, <https://www2.vetmed.ucdavis.edu/ohi/predict/index.cfm>.

⁶⁸ For example, see, NOAA’s following sites on climate and exploration tools: NOAA, Climate, <https://www.noaa.gov/climate>; and NOAA, Ocean Exploration and Research, <https://oceanexplorer.noaa.gov/technology/technology.html>.

⁶⁹ Briggs, “Climate security, risk, assessment and military planning,” p. 1052.

⁷⁰ Briggs, “Climate security, risk, assessment and military planning,” p. 1052.

⁷¹ Neiderud, “How urbanization affects the epidemiology or emerging infectious diseases,” p. 7. “Surveillance is of primary importance to monitor the burden of disease and will give both local authorities and the global community a chance for a quick response to public health threats.”

⁷² Costas Synolakis, “The Art of Predicting Unpredictable Tsunamis,” *Wall Street Journal*, Oct. 3, 2018, <https://www.wsj.com/articles/the-art-of-predicting-unpredictable-tsunamis-1538607558?mod=searchresults&page=1&pos=3>.

Asia.⁷³ In addition to working with local stakeholders to assess critical vulnerabilities,⁷⁴ the military should coordinate with agencies such as NOAA, which has models and equipment in place to warn of natural disasters. For example, NOAA has 39 tsunami detection buoys placed throughout the world's oceans and seas, most heavily in the Pacific.⁷⁵ However, despite these buoys and NOAA's predictive capabilities, Indonesia and other countries continue to rely on their own systems, with oftentimes disastrous results.⁷⁶ In Indonesia's case, its warning system was no longer operational in September 2018 due to lack of maintenance.⁷⁷ Because of its worldwide presence and resulting unique relationships and influence, the U.S. military is well-positioned to ensure coordination between developing countries and U.S. agencies such as NOAA, who have capabilities to help but sometimes lack the resources to effectively coordinate.

When natural disasters do occur, the U.S. military should maximize its strengths to complement the work of other relief organizations. For example, drone and satellite technology can monitor sudden migrations of people and detect infectious diseases that might be accompanying a group. Scientists have experimented with using drones to take samples of mosquitos and other potential carriers of disease, and this could be an effective way to discover contagions before they hit a large city, or to determine which parts of a city might be at risk once a contagion has taken root.⁷⁸ In addition, drones could be used to deliver self-spreading vaccines and other countermeasures to remote or highly infected locations.⁷⁹

⁷³ Tasha Wibawa and Farid M. Ibrahim, "Indonesia tsunami early-detection buoys haven't worked for six years due to 'lack of funding,'" *The New Daily*, Oct. 1, 2018, <https://thenewdaily.com.au/news/world/2018/10/01/indonesia-tsunami-early-detection-buoys/>.

⁷⁴ Briggs, "Climate security, risk, assessment and military planning," p. 1,062.

⁷⁵ NOAA, National Data Buoy Center, <https://www.ndbc.noaa.gov/dart.shtml>.

⁷⁶ Synolakis, "The Art of Predicting Unpredictable Tsunamis."

⁷⁷ John Mead, "How Tsunami Early Warning Systems Work, and Why Indonesia's System Failed," *RedZone*, Oct. 19, 2018, <https://www.redzone.co/2018/10/19/how-tsunami-early-warning-systems-work-and-why-indonesias-system-failed/>.

⁷⁸ Anne Gulland, "From self-spreading vaccines to 3D drugs: the tech that will stop a pandemic," *Telegraph*, Oct. 11, 2018, <https://www.telegraph.co.uk/news/0/self-spreading-vaccines-3d-drugs-tech-will-stop-pandemic/>; and Dieter Holger, "Microsoft Hopes to Prevent Epidemics Using Mosquito-sucking Drones," *Futurism*, June 16, 2015, <https://futurism.com/microsoft-hopes-prevent-epidemics-using-mosquito-capturing-drones/>.

⁷⁹ Saskia v. Popescu, "New Technologies to Fight Pandemics—From Prevention to Response," *Contagion Live*, Oct. 17, 2018, <https://www.contagionlive.com/contributor/saskia-v-popescu/2018/10/new-technologies-to-fight-pandemics-from-prevention-to-response>.

For a thorough review of research and technologies that could be used to prevent and respond to pandemics, see, Johns Hopkins Bloomberg School of Public Health, "Technologies to Address Global Catastrophic Biological Risks," 2018, http://www.centerforhealthsecurity.org/our-work/pubs_archive/pubs-pdfs/2018/181009-gcbr-tech-report.pdf.

Drones and satellites could also be used to monitor at-risk environmental ecosystems. Scientists are developing techniques to use these technologies to monitor the health of crops,⁸⁰ and the same ideas conceivably could be used to research the potential for zoonotic diseases to take root, especially in areas where human-animal interactions are unexpectedly increasing. The pandemic intelligence that results could be valuable not just for local predicting, but also for the cascade modeling described above. Due to its reach and resources, the U.S. military is ideally situated to assist in this type of research and should work with the governments of at-risk nations, other U.S. government agencies, and allies who share common interests in the at-risk areas.

Build Capacity and Change the Force

As cities greatly expand in the coming decades, many predict that only a small percentage of them will be healthy and properly regulated; most will contain large areas of at-risk populations, where a pandemic could easily take root and spread.⁸¹ Many cities in developing countries lack proper sanitation and sewage facilities and have insufficient healthcare infrastructure.⁸² To help correct this, the U.S. military should increase its partnering of civil-affairs and engineering resources with at-risk cities and development organizations to upgrade and build necessary infrastructure.⁸³ Because a significant reason for increasing urbanization is migration from rural areas,⁸⁴ at-risk governments should take steps to improve rural infrastructure and services as well. Again, the U.S. military has reach and resources that others cannot match. It could expand ongoing efforts, such as the Pacific Environmental Security Forum,⁸⁵ and make them more frequent and routine. It is essential to expand partnerships with and support the World Health Organization (WHO), USAID, and others to add facilities, provide training, conduct services in the most vulnerable areas, and help cities better plan for expansion and a proper balance of interaction between humans, animals, and

⁸⁰ Johns Hopkins, “Technologies to Address Global Catastrophic Biological Risks,” p. 5.

⁸¹ Sonia Shah, “How Cities Shape Epidemics,” *The Atlantic*, Feb. 25, 2016, <https://www.theatlantic.com/health/archive/2016/02/urbanization-pandemic-excerpt/470214/>.

⁸² Neiderud, “How urbanization affects the epidemiology of emerging infectious diseases,” p. 3. “Between 1990 and 2012, the group in urban settings which lacked sanitation actually significantly increased from 215 million to 756 million, which could be explained by population growth.”

⁸³ Based on this author’s experience as Economic Officer in Iraq, the U.S. military Civil Affairs teams were better at enacting effective and pragmatic changes than were USAID and other non-military organizations. This author worked closely with Civil Affairs team members who had agriculture, finance, and engineering expertise and who effectively shared it with Iraqi government officials and business managers to bring about positive change.

⁸⁴ Reyes et al., p. 127.

⁸⁵ For a description of the program and ongoing projects, see, “Pacific Environmental Security Forum,” U.S. Indo-Pacific Command, <http://pesforum.org/>.

delicate eco-systems.⁸⁶ As noted earlier, an effective partner could be China, whose focus on public infrastructure could be strengthened by America's traditional focus on policy reform and technical assistance in sectors such as healthcare.⁸⁷

The U.S. military should also upgrade its own capacity in line with the new threat environment. While we place a renewed focus on great-power competition with China and Russia and continue hedging against terrorism and other intermediate threats, we should also factor in human-security challenges such as pandemics. Our force structure should change to reflect this. For example, we should add more hospital ships and invest more heavily in health-related Artificial Intelligence (AI) capabilities, even if that means cutting warships. In addition to providing essential medical services, the hospital ships could be redesigned and updated to include extensive laboratory facilities and drone and AI platforms to assist with research, surveillance, and detection.⁸⁸ The drones could also be used to deliver medical supplies to hard-to-reach locations.

Some would argue that this change in force structure would cut against the grain of the National Defense Strategy's emphasis on traditional "lethality"⁸⁹ and its focus on great-power competition,⁹⁰ diverting money from much-needed warfighting capabilities. However, it is reasonable to argue that the American homeland and overall global security face a deadlier threat from a pandemic than from Chinese or Russian aggression. As an example, one should consider the Spanish flu that broke out in 1918, and by the spring of 1919, it "had sickened an estimated one-third of the

⁸⁶ Neiderud, "How urbanization affects the epidemiology of emerging infectious diseases," p. 1. "Adequate city planning and surveillance can be powerful tools improve the global health and decrease the burden of communicable diseases."

⁸⁷ International Crisis Group, "Central Asia's Silk Road Rivalries," *Europe and Central Asia Report*, vol. 245, July 27, 2017, p. 3.

⁸⁸ The U.S. Navy is considering upgrades to its hospital-ship capability, but the thinking seems too constricted for the human-security challenges, such as pandemics, that we face. The Navy's focus is more on care and not enough on research and prevention. Megan Eckstein, "Navy Studying New Hospital Ship, Intra-theater Mission Needs with Requirements Evaluation Team," *USNI News*, April 13, 2018, <https://news.usni.org/2018/04/13/navy-studying-new-hospital-ship-intra-theater-mission-needs-requirements-evaluation-team>.

⁸⁹ Consider the following statement by Undersecretary of Defense for Acquisition Ellen M. Lord: "With the first line of effort being lethality, the undersecretary said, 'make no doubt about it—we are about warfighting.'" Terri Moon Cronk, "DoD Official: Lethality, Readiness Drive Acquisition and Sustainment Reform," *U.S. Department of Defense*, May 2, 2018, <https://dod.defense.gov/News/Article/Article/1510642/dod-official-lethality-readiness-drive-acquisition-and-sustainment-reform/>.

⁹⁰ Consider the following statement from the 2018 National Defense Strategy: "The central challenge to U.S. prosperity and security is the reemergence of long-term, strategic competition by what the National Security Strategy classifies as revisionist powers." Office of the Secretary of Defense, *2018 National Defense Strategy of the United States of America* (Washington, D.C., 2018), p. 2, <http://nssarchive.us/wp-content/uploads/2018/01/2018-National-Defense-Strategy-Summary.pdf>.

world's population and may have killed as many as 50 million people,"⁹¹ including approximately 675,000 Americans.⁹² This black swan attacked a world completely unprepared for it, and its death toll was higher than that of the Great War that immediately preceded it.⁹³ A more recent example is the swine flu pandemic of 2012, which, according to CDC, killed an estimated 284,500 people.⁹⁴

Security against this kind of non-traditional threat involves a different kind of lethality, one in which we invest in capabilities that are designed to preempt and destroy contagions rather than people and infrastructure. Adding hospital and laboratory ships, and the associated drone and AI capabilities, would greatly improve our ability to provide medical services and research and surveillance support at the most at-risk locations. It would also demonstrate a positive U.S. presence to huge segments of the developing world's population.⁹⁵ From a budgetary perspective, consider that "the cost to the global economy of SARS is estimated to have been \$54 billion, according to the World Bank, while the organization estimates that a 'severe flu pandemic' could cost over \$3 trillion, nearly five percent of global GDP."⁹⁶ Even if a newly designed hospital and laboratory ship carried a price tag of \$2 billion or so, the potential of catastrophic loss from a pandemic dwarfs the investment in human security that would come with the procurement of a fleet of these ships.⁹⁷ When one considers that the

⁹¹ Lindsey Konkel, "Why Was the 1918 Influenza Pandemic Called the 'Spanish Flu'?" *History*, May 22, 2018, <https://www.history.com/news/why-was-the-1918-influenza-pandemic-called-the-spanish-flu>.

⁹² "Spanish Flu," *History*, last updated Feb. 22, 2019, <https://www.history.com/topics/world-war-i/1918-flu-pandemic>.

⁹³ For an analysis of World War I deaths, see, David Stevenson, *Cataclysm: The First World War as Political Tragedy* (New York: Basic Books, 2004), pp. 442-243.

⁹⁴ Frangoul, "Counting the cost of a global epidemic."

⁹⁵ For a good analysis of the capabilities of U.S. Navy hospital ships and the soft-power heft that comes with them, see, Joseph Trevithick, "Have Mercy! The US Navy Now Wants to Retire One of Its Two Hospital Ships," *The War Zone*, March 17, 2018, <http://www.thedrive.com/the-war-zone/19339/have-mercy-the-us-navy-now-wants-to-retire-one-of-its-two-hospital-ships>. This author has seen the huge impact that hospital ships can have on U.S. diplomacy. When he served in Cambodia, the USNS Mercy conducted a humanitarian visit as part of Pacific Partnership 2010. The doctors and nurses on the ship treated thousands of Cambodians for health problems. This left an impact that will stay with those people—and their families, friends, and villages—for the rest of their lives. Overall, the Pacific Partnership 2010 mission visited six Southeast Asian countries and treated 109,754 patients. For an overview of the mission, see, Pacific Partnership 2010 Public Affairs, "Pacific Partnership 2010 Ends With Many Firsts," *Air Force Medical Service*, Sept. 30, 2010, <https://www.airforcemedicine.af.mil/News/Display/Article/426709/pacific-partnership-2010-ends-with-many-firsts/>.

⁹⁶ Frangoul, "Counting the cost of a global epidemic."

⁹⁷ For a cost estimate and a discussion on the Navy's thinking on a redesigned hospital ship, see, Joseph Trevithick, "The Navy Eyes Replacing Its Hospital Ships With A Fleet of Smaller Medical Vessels," *The Drive*, April 16, 2018, <http://www.thedrive.com/the-war-zone/20156/the-navy-eyes-replacing-its-hospital-ships-with-a-fleet-of-smaller-medical-vessels>. This author increased the cost figure of \$1.5 billion mentioned in the article to \$2 billion in recognition that the ships he envisions would possess more capabilities.

majority of the world's growing urban population resides "in a coastal zone or a zone with distinct coastal influence,"⁹⁸ the argument to update the Navy's human-security capabilities becomes even more cogent.

Moving Forward

As climate change and urbanization progress, pandemics are likely to occur, and American national-security professionals must consider this worst-case scenario as they develop strategies and policies. If we actively pursue preventive and mitigating actions, the outcome of a pandemic could be a disaster that can be managed, contained, and learned from. The alternative will be more Mogadishus, or worse. IGOs play an important role in encouraging international debate and in providing limited resources; however, to address the looming threat of deadly contagion, we must take aggressive and pragmatic action. Due to its reach and resources, the U.S. military is well-placed to lead. It should partner with governments and NGOs, leveraging existing alliances and building new ones. Primary actions should include conducting research and creative predictive modeling; ensuring effective surveillance and detection efforts; and upgrading and building infrastructure in high-risk areas. The military should also revise its capabilities to better address the growing pandemic threat.

It is appropriate to close with an overarching statement of purpose from the U.S. National Biodefense Strategy: "The United States will use all appropriate means to assess, understand, prevent, prepare for, respond to, and recover from biological incidents—whatever their origin—that threaten national or economic security."⁹⁹ Due to the interconnectedness of today's world, it is hard to imagine a pandemic that would not have potential to threaten American security. We must approach the fight against pandemics aggressively, detecting, containing, and destroying a pandemic when it attacks, and the rest of the time working to prevent and prepare for the next pandemic.¹⁰⁰ As the climate warms and eco-systems change, new and deadlier contagions will enter the fight, and we must stay engaged.¹⁰¹



⁹⁸ Roland von Glasow, Tim D. Jickells, Alexander Baklanov, Gregory R Carmichael, Tom M. Church, Laura Gallardo, Claire Huges, Maria Kanakidou, Peter S. Liss, Laurence Mee, Robin Raine, Purvaja Ramachandran, R. Ramesh, Kyrre Sundseth, Urumu Tsunogai, Mitsuo Uematsu, and Tong Zhu, "Megacities and Large Urban Agglomerations in the Coastal Zone: Interactions Between Atmosphere, Land, and Marine Ecosystems," *Ambio*, Oct. 18, 2012, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3547459/>.

⁹⁹ National Biodefense Strategy, p. 3.

¹⁰⁰ For a good discussion on the need for continuous vigilance, see, Gray, *Fighting Talk*, pp. 7-10. Gray refers to the concept as a "war-peace-war continuum."

¹⁰¹ As noted above, the increased interaction of humans, animals, and previously untouched environmental ecosystems will likely lead to new contagions infecting humans. There are also unknown viruses lurking in the Arctic. For a good discussion on the discovery of previously unknown viruses buried beneath permafrost, see, Robinson Meyer, "The Zombie Diseases of Climate Change: What lurks in the Arctic's thawing permafrost?" *The Atlantic*, November 6, 2017, <https://www.theatlantic.com/science/archive/2017/11/the-zombie-diseases-of-climate-change/544274/>.