# Mitigating Climate Change's Impact on Tick-Borne Zoonotic Disease Emergence

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**Executive Summary:** Disease transmission from animals to humans — called a zoonotic disease — is responsible for nearly 60% of emerging infectious diseases. While zoonotic diseases already pose a major risk to humanity, global climate change and its causal human behaviors are compounding zoonotic disease risk. Dynamic species distributions, increased species overlap, and alterations in human land use increase the risk of disease transmission from non-humans to humans. Ticks, which carry many human disease-causing agents, are a primary example. As 23% of emerging infectious diseases globally are spread by blood-feeding arthropods, such as ticks, managing and monitoring tick distributions and their overlap and potential contact with humans is vital to decrease the risk of zoonotic disease transmission. While some programs are already in place, expanding current and implementing new programs across the globe is pertinent. We propose enhancing international collaboration and communication efforts through intergovernmental organizations such as the United Nations (UN) and the World Health Organization (WHO), to better research, monitor, and mitigate the risk of tick-borne zoonotic disease. By focusing international efforts on ticks, subsequent zoonotic disease-climate change research and monitoring efforts can be done across species.

## I. Statement of Issue

Presently, zoonotic diseases account for 60% of all emerging infectious diseases (Jones et al. 2008) and, due to globalization and climate change, pose one of the most serious threats to global human security (Norman et al. 2020). These diseases are also some of the most difficult to trace and control due, in part, to the complex interactions that exist between wildlife and the environment (Greiner et al. 2015). As such, implementing robust surveillance, reporting, and research systems are crucial for mitigating or avoiding these risks altogether (Burki 2020). Within the US, zoonotic diseases that pose the most serious threat to public health are spread by blood-feeding arthropods (e.g., mosquitoes, lice). Among these zoonotic vector-borne diseases, 95% of those which are reported in the US are tick related (Eisen et al. 2017). Additionally, since 1984, ten new tick-borne diseases that pose a risk to humans have been identified (Paddock and Telford 2011).

Climate change is increasing not just the distribution of ticks across the US, but also the probability of human-tick interactions. As shown in Figure 1, climate change and dynamic human land use patterns are resulting in newly suitable habitats for disease-spreading ticks (Sonenshine 2018). As temperatures warm, tick habitats have expanded into novel latitudes and elevations (James et al. 2015). Additionally, altered seasonal weather patterns allow for increased activity of tick populations throughout the year (Gray et al. 2009), facilitating further human interactions. Finally, climate change alters the spatial distribution of migratory mammalian species (e.g., deer, foxes, elk), which can serve as new food and transportation systems for hitchhiking ticks (Sonenshine 2018). Ultimately, this dynamic mix between alterations in tick and animal distributions, and the increased availability of suitable tick habitats, increases the risk and prevalence of tick-borne diseases in humans, livestock, and wildlife (Grey et al. 2009).

The effects of climate change on increased tick distribution within the US are further exacerbated by urban development and human activity. As humans continue to use land in novel ways, through development and recreation, the barrier between ticks and humans is eroding. The wildland-urban interface (WUI) is a primary example, wherein development occurs on previously undeveloped natural spaces (Radeloff et al. 2005). Expansion of the WUI has several ecological and economic downsides, such as reducing biodiversity, increasing susceptibility to wildfire, and increasing human-wildlife interactions (Radeloff et al. 2005). These interactions at the WUI have resulted in an increased prevalence of tick-borne diseases such as Spotted Fever Rickettsiosis (Heitman et al. 2019), a 46% increase in the number of reported cases in the US from 2016 to 2017, and human babesiosis (Vannier et al. 2015).

The dynamic intersection of climate change, species distributions, and human development poses an increasing threat for widespread tick-borne zoonotic disease transmission. While monitoring, tracking, and preventing tick-borne diseases pose serious challenges, leveraging insights from research into zoonotic diseases across the globe will provide the means to adapt to and increase resilience in a changing world.

## II. Policy Options

### *i. Option 1: Enhance International Monitoring and Communication*

The increased rate of tick-borne zoonotic disease emergence requires international monitoring and communication efforts, especially since 1) human exposure to disease-carrying ticks is predicted to increase under climate change and rising urbanization; 2) tick-borne diseases are technically challenging to diagnose, especially in resource-strapped areas; 3) if left undetected, these diseases can cause severe, chronic health problems requiring expensive, long-term care; and 4) tick-related zoonosis is seen across the globe. Current international efforts to identify zoonotic diseases struggle to identify and prevent spread, as seen in recent Ebola, Zika, and COVID-19 outbreaks. These shortfalls have contributed to a lack of funding for, and a reduced ability to monitor and detect outbreaks of, intergovernmental organizations. Strengthening international systems is crucial to more effectively identifying and mitigating zoonotic disease threats before they become public health crises. Intergovernmental organizations such as the UN's environment program or the WHO, which work to identify and mitigate future pandemics, should be supported and expanded. Additionally, smaller but more specific programs such as Global Early Warning System for Major Animal Diseases (GLEWS), Food and Agriculture Organization of the United Nations (FAO) and the World Organization for Animal Health (OIE) should also be bolstered. Increased funding and unsuppressed monitoring capabilities for intergovernmental programs (and the one hundred public health labs around the United States) will increase the number of scientists and health professionals available to monitor disease outbreaks and inform other nations of their findings and decrease shortcomings of a decentralized approach. Additionally, public support of intergovernmental organizations from governments can go a long way in enhancing support from the public of each country, potentially aiding in the

efficacy of these intergovernmental organization's zoonosis mitigation programs. As both government leaders and the general public are stakeholders in global health, ever changing political climates and inconsistent communication and support for intergovernmental organizations from governments can prove a serious challenge to this policy option. In summary, more support (financial, personnel, and otherwise) for intergovernmental organizations will help detect, prevent, and mitigate future tick-borne zoonotic disease outbreaks.

*Advantages*

- Formal use of a multinational surveillance network ensures that life-saving information will be shared in an egalitarian fashion, preventing some countries from having advanced notice of outbreaks before others.
- These systems can be maintained across leadership and political climates more effectively as no one government is responsible.
- The bolstering of tick-borne disease programs can lay the groundwork for expanding work on other species.

*Disadvantages*

- Integrated and comprehensive monitoring programs require increased continual funding mechanisms for intergovernmental organizations, such as the UN or WHO, that are guaranteed by major contributing countries.
- Individual nations can suppress the ability of UN scientists to accurately monitor outbreaks and public health in their countries if sovereignty is invoked.

*ii. Option 2: Increasing and integrating passive tick surveillance into pre-existing hunting and agriculture pipelines*

Robust tick surveillance systems are necessary for mitigating not just the health risks of climate change-induced tick-borne diseases, but also their associated costs. Currently, Lyme disease alone costs the US healthcare system between $712 million and $1.3 billion annually (Adrion et al. 2015). Individual medical costs for Lyme disease patients can cost between $4,200-$7,500 per patient, depending on disease severity (Mac et al. 2019). Lowering the financial burden of tick-borne disease begins with protecting individuals from exposure, which is achievable through robust surveillance programs. Tick-borne disease surveillance activities provide public health systems with crucial information needed to accurately anticipate possible disease hotspots, quickly follow up with targeted interventions (e.g., tick population control via trapping or insecticide spraying, closing park areas identified as outbreak zones to limit human exposure), and avoid preventable spillover transmission to people.

Unfortunately, the active surveillance systems that we currently rely upon to identify and suppress tick-borne diseases are often incredibly labor intensive and expensive. In Pennsylvania, a cost analysis showed that a statewide active surveillance campaign would cost between $1-5 million, a figure that was deemed unachievable with state funding alone (Mensch et al. 2016). To provide alternative, cost-effective surveillance options, states can consider bolstering surveillance programs by incorporating large-scale, passive surveillance activities into ongoing wildlife and agriculture reporting systems. For example, the US Fish and Wildlife Service (USFWS) can incorporate passive tick surveillance and reporting methods into existing US hunting infrastructures. After a successful hunt, licensed hunters must submit a carcass tag according to law. The USFWS could require hunters to indicate whether or not ticks were found on the game animal on these carcass tags. Incentivizing tick reporting could be accomplished through several means. First, the USFWS could provide pre-stamped envelopes, a cost-effective mailing option that can double the typical mail-back response rate so that ticks are sent directly to laboratories for further pathogen testing (Urban, Anderson, and Tseng 1993; Edwards et al. 2002). Second, as advocated in South Carolina Bill 489, an extra $1-5 could be added to hunting license fees. This would raise funds needed to pay a bounty reward to hunters that submit ticks for testing. Lastly, in cases where hunters must submit a carcass for inspection, tick surveillance can be done directly by USFWS staff.

Alternatively, or additionally, the United States Department of Agriculture (USDA) could provide a similar reporting workflow for ticks collected on livestock. The Federal Meat Inspection Act §604 and §605 already requires post-mortem inspection of cattle, pigs, goats, and sheep (all of which can serve as tick hosts) carcasses that are intended for commercial meat production. Inspections are conducted by USDA Food Safety and Inspection Service (FSIS) personnel, some of whom could be mobilized into a task force responsible for a) examining livestock carcasses and hides for tick infestation, and b) submitting any ticks discovered during the slaughterhouse process to labs for further testing.

*Advantages*

- Passive surveillance techniques are low-cost and fit within existing programs and monitoring frameworks.
- These techniques provide critical epidemiological data, including state and county-level status for specific tick species, tick-borne pathogen presence, and tick host-seeking behavior.
- By increasing monitoring on the ground by hunters, farmers, and government officials we strengthen the identification of disease risk and can inform public health professionals where to direct more expensive active control efforts.

*Disadvantages*

- To be effective, this approach requires high compliance with hunters and livestock owners who may often be working on an "honor system" to report.
- Due to the data collection methods and migratory nature of wild animals, data obtained via passive surveillance may be inconsistent regarding tick location and time of collection.
- Hunters will not report ticks from game hunted illegally, which may be important data.
- Effort and money will need to be spent to educate hunters and livestock owners on how to identify and report ticks.

*iii. Option 3: Promote community resiliency against tick-borne diseases with public health education campaigns*

Well-crafted public health communication campaigns will inform behaviors, educate and motivate audiences, and improve the health of large-scale communities. Within the US, health communication campaigns have been a key component of broad intervention efforts against numerous infectious diseases, including tick-borne diseases. States already experiencing a high burden of tick-borne illnesses currently use public health education campaigns to prevent new disease incidences. However, similar practices are frequently not maintained in states that historically have lower disease incidences. To prepare for increased tick-borne disease cases in light of climate change, this latter group of states can prepare by initiating Lyme and other tick-borne disease education campaigns among the public.

Under this option, state governments will fund an effective, two-pronged public awareness campaign. First, tick-borne education campaigns can be directed towards those most at risk of contracting disease, such as hunters, hikers, and the Scouts BSA of the USA groups. As a second approach, specialized prevention education will be provided to healthcare providers, such as physicians, school nurses, and lab technicians. The scope of the media and education campaign will depend on financial availability, but numerous low-cost options exist. The Center for Disease Control and Prevention has developed a free communication toolkit (CDC 2019), which includes radio broadcasts, brochures, trail signs, and fact sheets, to help state and local health professionals prevent Lyme disease. Overall, education and communication may help mitigate emergence risk and the potential spread of tick-borne zoonotic disease.

*Advantages*

- Public health campaigns can prompt public discussion of and community mobilization around health issues, leading to changes in public policy.

- Educating individuals in health subjects gives them agency over their own health and decision making.
- Campaigns disseminate well-defined, behaviorally focused messages to large audiences repeatedly over time, in an incidental manner, and at a low cost per individual.
- Promoting healthy behaviors among individuals may lead to other secondary, beneficial health outcomes (e.g., encouraging people to wear protective clothing to ward off tick bites can also keep them safe from mosquitoes, which can also be zoonotic disease vectors).
- Public health education has proven very efficacious when the behavior change goal is simple and the campaign focuses on changing social norms.

*Disadvantages*

- Public health education campaigns may have to compete against powerful political and social norms as well as behaviors driven by habit.
- To permeate the entire community, multiple public health education campaigns often need to be run simultaneously and be tailored to reflect different community conditions and values.
- Short term education programs may have difficulty in achieving a community-wide impact as most changes in health behavior require constant reinforcement.
- To truly initiate widespread behavior change, many public health education campaigns often need to be accompanied by changes in top-down policies and regulations.
- Public health education campaigns can have limited effect if trust does not exist between researchers, health practitioners, and community participants.

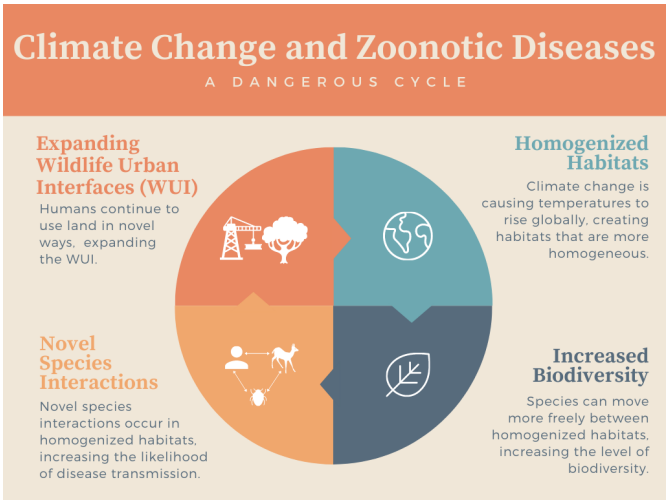


**Figure 1**: Infographic of the dangerous cycle that climate change creates for zoonotic diseases. Humans expand the wildlife-urban interface, and climate change continues to homogenize habitats, creating areas of increased biodiversity where novel species interactions can occur. These interactions present an increased risk for the spread of zoonotic diseases.

## II. Policy Recommendation and Conclusion

To better research, monitor, and mitigate the increasing risk of tick-borne zoonotic disease due to climate change, we recommend Policy Option 1: Enhance International Monitoring and Communication. While Policy Options two and three are smaller scale programs, which can be adapted by local governments, tick-borne zoonotic disease is a global issue, requiring global solutions. While there are financial and logistical disadvantages, robust funding and enhanced and unsuppressed monitoring capabilities of intergovernmental organizations will mitigate noncooperation by any one country. This will also facilitate communication between agencies, such as the WHO and UN. Under Policy Option 1, both international governments and the general public are stakeholders. Due to the ever-changing political climates, governments may provide inconsistent financial support and drive public untrust in intergovernmental organizations. However, as both governments and citizens are stakeholders in the wellbeing of their citizens and in themselves, ultimately Policy Option 1 should have a net positive impact on the primary stakeholders. Additionally, intergovernmental organizations'

efforts in data collection and sharing will better our understanding of climate change's role in tick-borne zoonotic disease emergence and risk. International collaboration on tick-borne diseases will also provide a platform to develop new and enhance current zoonotic disease-climate change research and monitoring efforts. In turn, helping to identify and mitigate future novel disease emergence and public health crises.

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