Climate Changes Impacts on Fire Regimes, Plant Invasions, and Tick-Borne Diseases (RC-2636)

Objective

Tick-borne diseases (TBDs) represent a major public health threat in North America, particularly for military personnel training on Department of Defense (DoD) installations. Ecological theory predicts that climate change will likely alter vector-borne disease transmission by a variety of direct and indirect pathways. This project proposes to explore several of the predicted consequences of climate change, including altered fire regimes and plant communities and their interactions with wildlife, for human risk of exposure to TBDs in the southeastern United States (U.S.). Research will involve an integrated effort to understand the consequences of climate change for TBD risk and human health, and it will lead to making specific, actionable recommendations to predict and ameliorate future changes in pathogen exposure pathways.

Project-specific objectives are to:

1. Evaluate the interactions between fire and plant invasions spanning a gradient in fire management, invasive plant distribution and abundance, and climatic conditions across the southeastern U.S.
2. Quantify the effects of fire and plant invasions, and their interactions, for variation in wildlife abundance, tick abundance, tick infection rates, and TBD risk to humans.
3. Calibrate a spatially explicit model of TBD risk in response to fire-invasion interactions and incorporate simulations of climate change scenarios to examine the responses of fire, plant invasions, wildlife, TBD risk, and their interactions.

Technical Approach

Sixteen active DoD installations will be used to empirically examine the interactions between fires and plant invasions spanning a climate gradient across the southeastern U.S. Across all 16 sites, and using gradients in fire management, wildfire occurrence, and plant invasions, multiple annual surveys of vegetation, wildlife, tick abundance, and tick-borne pathogen prevalence will be performed. In addition, mechanistic experiments will be conducted to quantify plant-fire-tick interactions. Using these empirically derived estimates from the field and laboratory, a structural equation modeling (SEM) framework will be followed to test the direct and indirect effects of climate on fire regimes, plant invasions, host abundance, tick abundance, pathogen prevalence, and TBD exposure risk.

In addition, a physiologically-based terrestrial biosphere model will be developed that is capable of capturing the interactions between successional dynamics, biogeochemistry, and disturbance across a wide range of spatial scales to forecast the effects of climate change and forest management on wildfires, prescribed burns, plants invasions, and native vegetation. These estimates will then be fed back into the SEM to elucidate future effects of climate change, plant invasions, fire regimes, and their interactions, for wildlife, tick abundance, pathogen prevalence, and TBD risk under various climate change scenarios. The overarching hypothesis that variation in fire and plant invasions are the dominant factors explaining TBD exposure risk on the modern landscape will be tested. In addition, the project will test the prediction that the indirect effects of climate change through changes in fire and plant invasion dynamics will have a greater impact on TBD exposure risk than will the direct effects of climate change.

Benefits

Recent research has addressed only individual components for the effects of climate, fire, and invasions on TBD exposure pathways. No effort has evaluated the many potential interactions and feedbacks that may mediate the effects of any one component on the transmission of TBDs. This proposed research will provide a leap forward in understanding the multitude of factors that determine TBD risk. The results of the study will be directly applicable to predicting TBD risk under non-stationary conditions, which can then be used to inform management decisions for mitigating disease risk currently and in the future. Outputs of this research will include disease risk maps, early warning systems, and management guidelines that explicitly account for pathogen exposure risk. A web-based interface for forecasting TBD risk under alternative management scenarios will be created that is accessible to land managers at DoD installations and other federally managed sites. Movements of military personnel could be adjusted to account for areas of high risk, and the strategic deployment of other management approaches will be enhanced. The combination of outputs and deliverables from these efforts will not only benefit personnel operating on military installations in the southeastern U.S. but potentially will offer widespread benefits to public health throughout the region.

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