

Final Project Report

Southeast Climate Adaptation Science Center Project# 040 FY2018-2019

1. ADMINISTRATIVE:

Principal Investigator: Steven D. Frank

Institution: North Carolina State University

Project Title: Effects of Urbanization on the Conservation Value of Forests

Agreement Number: G19AP00041

Date of Report: January 11, 2021

Period of Performance: 8/30/18-10/30/20

Total Cost: \$48,002

2. PUBLIC SUMMARY: Cities and suburbs are growing in size throughout the U.S. and particularly in the Southeast. As cities and suburbs expand they encroach upon preserved areas, like national wildlife refuges, and divide forests into smaller pieces. Forests next to cities and suburbs are exposed to high temperatures, pollution, insect pests, exotic plants, and other things that can threaten forest health. Unfortunately, land managers do not have information about how these urban factors affect native plants and animals, including threatened and endangered species, that call forests home. We synthesized existing scientific knowledge about the effects of urbanization, particularly the urban heat island effect, to inform management decisions and to achieve conservation goals. Our synthesis will result in scientific papers describing effects of urbanization on forests, with dissemination of relevant findings to land managers in other formats. This project identified knowledge gaps and areas where new research is critical. We cannot rely on a few large, pristine, and protected forests to fulfill the nation's conservation goals. This project informs the role that urban forests can play.

3. TECHNICAL SUMMARY: Urban and suburban expansion are primary threats to U.S. forests and the plants and animals that live in forest ecosystems. Urbanization imposes biotic stressors such as invasive species, and abiotic stressors, such as pollution and high temperatures, on forests. Our goal was to synthesize information on factors, particularly the urban heat island effect, that affect urban forest quality for plants and animals, identify knowledge gaps that impede forest management, and propose future research directions to fill those gaps. We reviewed scientific literature to address the following questions:

- 1) How do abiotic factors, particularly heat, affect forest quality for different plant and animal taxa;
- 2) How do biotic factors, such as tree pests exacerbated by heat, affect forest quality for different plant and animal taxa; and
- 3) How does urban forest size and spatial arrangement interact with urbanization to affect forest quality?

We found that the urban heat island effect can alter soil moisture and processes, increase tree stress, and increase the abundance of some arthropod pests in forests adjacent to urban areas. These and other urban-induced changes can make forests less hospitable for some plant and animal species. Expected products are peer-reviewed review papers and products such as webinars accessible to stakeholders.

4. PURPOSE AND OBJECTIVES: The issue addressed by this project is that large tracts of protected forest cannot be relied upon to meet the nation's conservation objectives. Forests are increasingly being divided by urbanization and even protected lands are meeting urbanization at their edges. Land

managers do not have adequate information to predict and mediate the consequences of urbanization on forest habitats. Our specific original objectives were to address the following questions:

- 1) How do abiotic factors, such as heat and pollution from light, noise, and chemicals, affect forest quality for different plant and animal taxa;
- 2) How do biotic factors such as tree pests and invasive plants and animals affect forest quality for different plant and animal taxa; and
- 3) How does urban forest size and spatial arrangement interact with abiotic and biotic factors to affect forest quality?

We narrowed our objectives to focus primarily on the effects of urban heat islands, as listed in section 3, due to the amount of literature on this and other topics and the funding provided.

5. ORGANIZATION AND APPROACH: We conducted a literature review using standard methodology to find relevant articles among scientific journals in multiple disciplines. Our primary search tool was Web of Science. We also searched within relevant articles for other references and investigated articles that have cited relevant articles since they were published. Our review focused on the three primary questions posed in the objectives within forest ecosystems native to the Southeastern United States. Our goals were to synthesize existing research on the urbanization threats sustained by urban forests, identify gaps in knowledge, and propose research priorities to address knowledge gaps most relevant to conservation and land management. We expect to publish the review paper(s) in high impact journals read by scientists in diverse disciplines. In addition, we will distill information into formats more accessible to stakeholders such as webinars, blog posts, and brief information sheets.

6. PROJECT RESULTS: The goal of this project was to produce a review paper so we do not have quantitative results. The paper is still being edited with a final version expected early spring 2021. Overall the review indicates that the urban heat island effect can change forest habitats in ways that could negatively affect species of conservation concern. For example, high temperatures and great transpiration by trees can reduce soil moisture making the habitat less hospitable for some plant and arthropod species. Pests on trees can increase potentially reducing canopy cover and changing species diversity. Research also suggests that the effects of atmospheric warming on urban forests may foreshadow effects of greater climate warming.

7. ANALYSIS AND FINDINGS: Overall the review indicates that the urban heat island effect can change forest habitats in ways that could negatively affect species of conservation concern. For example, high temperatures and great transpiration by trees can reduce soil moisture making the habitat less hospitable for some plant and arthropod species. Pests on trees can increase potentially reducing canopy cover and changing species diversity. Research also suggests that the effects of atmospheric warming on urban forests may foreshadow effects of greater climate warming.

8. CONCLUSIONS AND RECOMMENDATIONS: Our review uncovers significant evidence that urbanization generally, and the urban heat island effect in particular, have consequences for forest habitats and the plants and animals that rely on them. Our review will help land managers understand these risks and help them determine how to monitor forests. For example, forest edges are more influenced by urban warming and our review will help managers determine how far from an edge they could expect habitat and species changes. A natural extension of this work is to follow up with research on the many understudied aspects of how urbanization affects forests. Observational and manipulative experiments could help determine the consequences for species of management concern and how to mitigate them.

9. MANAGEMENT APPLICATIONS AND PRODUCTS: Our review uncovers significant evidence that urbanization generally, and the urban heat island effect in particular, have consequences for forest habitats and the plants and animals that rely on them. Our review will help land managers understand these risks and help them determine how to monitor forests. For example, forest edges are more influenced by urban warming and our review will help managers determine how far from an edge they could expect habitat and species changes. A natural extension of this work is to follow up with research on the many understudied aspects of how urbanization affects forests. Observational and manipulative experiments could help determine the consequences for species of management concern and how to mitigate them.

10. OUTREACH AND COMMUNICATION: Our review paper is not completed so we have not yet finished our outreach materials either. However, The PI speaks frequently to some stakeholders, such as urban foresters, about the consequences of the urban heat island for tree health.