

## Overview

Recreational activities, particularly hiking and biking, have experienced a notable surge in popularity, a trend exacerbated by the onset of the COVID-19 pandemic. This increased engagement presents a unique opportunity for individuals to establish meaningful connections with forested landscapes. While the uptick in recreational usage is positive for human well-being and nature appreciation, it concurrently raises concerns about potential impacts on forest health, specifically pertaining to soil quality, wildlife habitats, and the broader ecological equilibrium within forest ecosystems.

Numerous studies have underscored the positive impacts of outdoor recreation on human well-being and mental health, emphasizing the importance of nature experiences in mitigating stress and promoting physical activity (Bowen et al., 2018; Bratman et al., 2019). However, the dynamic interplay between heightened recreational activities and potential consequences for forest health necessitates a comprehensive understanding of the ecological implications.

The Forest Ecosystem Monitoring Cooperative (FEMC) embarked on a project spanning 2022 and 2023, specifically designed to delve into the multifaceted interactions between recreation, soil vulnerability, wildlife disturbance, and overall forest health. By employing advanced geospatial analysis techniques, the project aimed to elucidate how recreational activities impact soil quality and wildlife habitats. Moreover, the study sought to create actionable products that could aid in the effective management of recreation in forest ecosystems.

The findings of this research endeavor are expected to contribute valuable insights for land managers, conservationists, and policymakers, facilitating a balanced approach that considers both the benefits of recreation and the conservation of vital ecological components. By exploring the nuanced relationships between human activities and forest health, the project aims to inform sustainable management practices, ensuring that recreational engagement with forested landscapes can coexist harmoniously with the preservation of ecological integrity.

This project aimed to investigate the impact of recreational hiking and biking on forest health. The analysis utilized several geospatial data sources, including ForWarn sentinel data, STRAVA recreational use data, NLCD forest data, and USDA soil survey data. The primary objectives were to determine whether recreational activities affect canopy health and if so, whether those effects can be detected with ForWarn; identify areas where soils are more susceptible to recreational use; and assess the disturbance of wildlife in forested landscapes used for recreational activities.

## Methods

1. ForWarn Sentinel data: We integrated ForWarn sentinel data to monitor forest health indicators, such as vegetation stress and disturbance events, and examined whether these metrics could be linked to recreational activities.
2. NLCD Forest and USDA Soil Survey data: We combined NLCD forest data and USDA soil survey data to create geospatial datasets that allowed us to identify areas with soils susceptible to recreation and to assess how these soils were being used on the landscape.
3. Wildlife disturbance analysis: Our research also explored the potential impact of recreation on wildlife. We mapped areas where wildlife was likely to be disturbed by outdoor activities, and determined both how often that disturbance occurs and the average size of undisturbed forested parcels.
4. STRAVA recreational use data: We leveraged STRAVA's recreational use data, which shows usage density on all trails across the project region, to assess the spatial distribution and intensity of hiking and biking activities—this added an additional dimension to our above analyses.

## Strava Forwarn Findings

### Canopy Health and Recreational Use:

- Significant but weak positive correlation between forest canopy health and recreational use.
- Areas with hiking and biking recreation tend to exhibit a greener and healthier forest canopy.
- Two-sample t-test shows a statistically significant difference, reinforcing the positive relationship.

### Remote Sensing with ForWarn:

- ForWarn NDVI deviance from norm during the growing season used for remote sensing.
- Statistically significant relationship found between areas with recreational activities and generalized changes in forest canopy health.
- Correlation indicates a positive association, but causative link not established.

### Positive Relationship Implications:

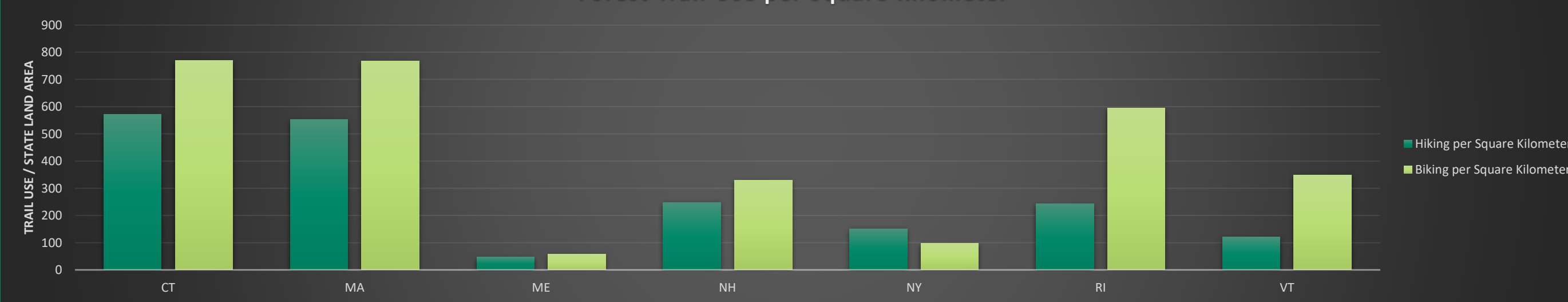
- Positive correlation implies that recreation-prone areas have a greener and healthier forest canopy during the growing season.
- Statistical significance reinforces the observation of improved forest health in recreation-prone areas.
- Cautious interpretation required, acknowledging the complexity of forest ecosystems and the multifactorial nature of observed changes.

### Recreation and NDVI Relationship:

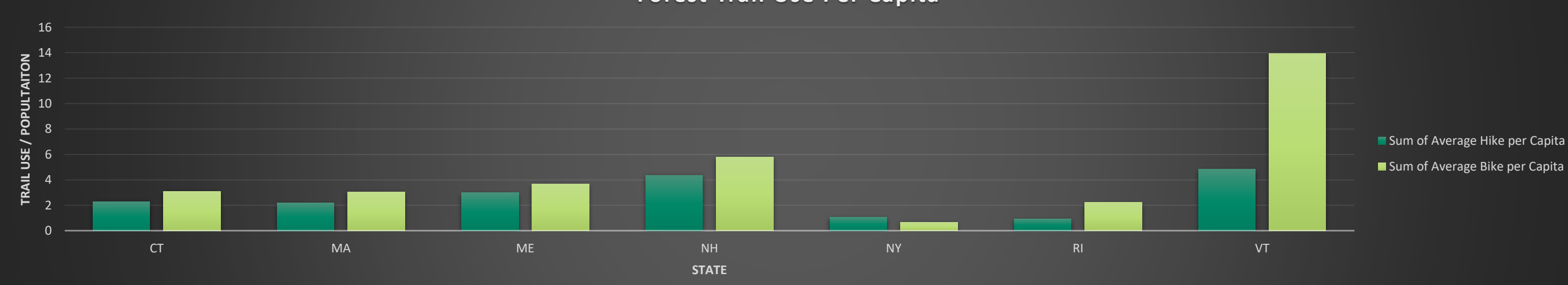
- Linear model reveals nuanced associations between Strava hiking/biking and NDVI deviance.
- Intercept (8.369e+00) denotes baseline mean NDVI deviance.
- Hiking shows a slight, statistically significant decrease (p-value: 0.008668), while biking exhibits a slight increase with significance (p-value: 0.000486).
- Limited explanatory power (Multiple R-squared: 8.939e-05, Adjusted R-squared: 7.79e-05) emphasizes the complexity of recreational impacts on forest health.

## State Specific Hiking and Biking Use Findings

Forest Trail Use per Square Kilometer

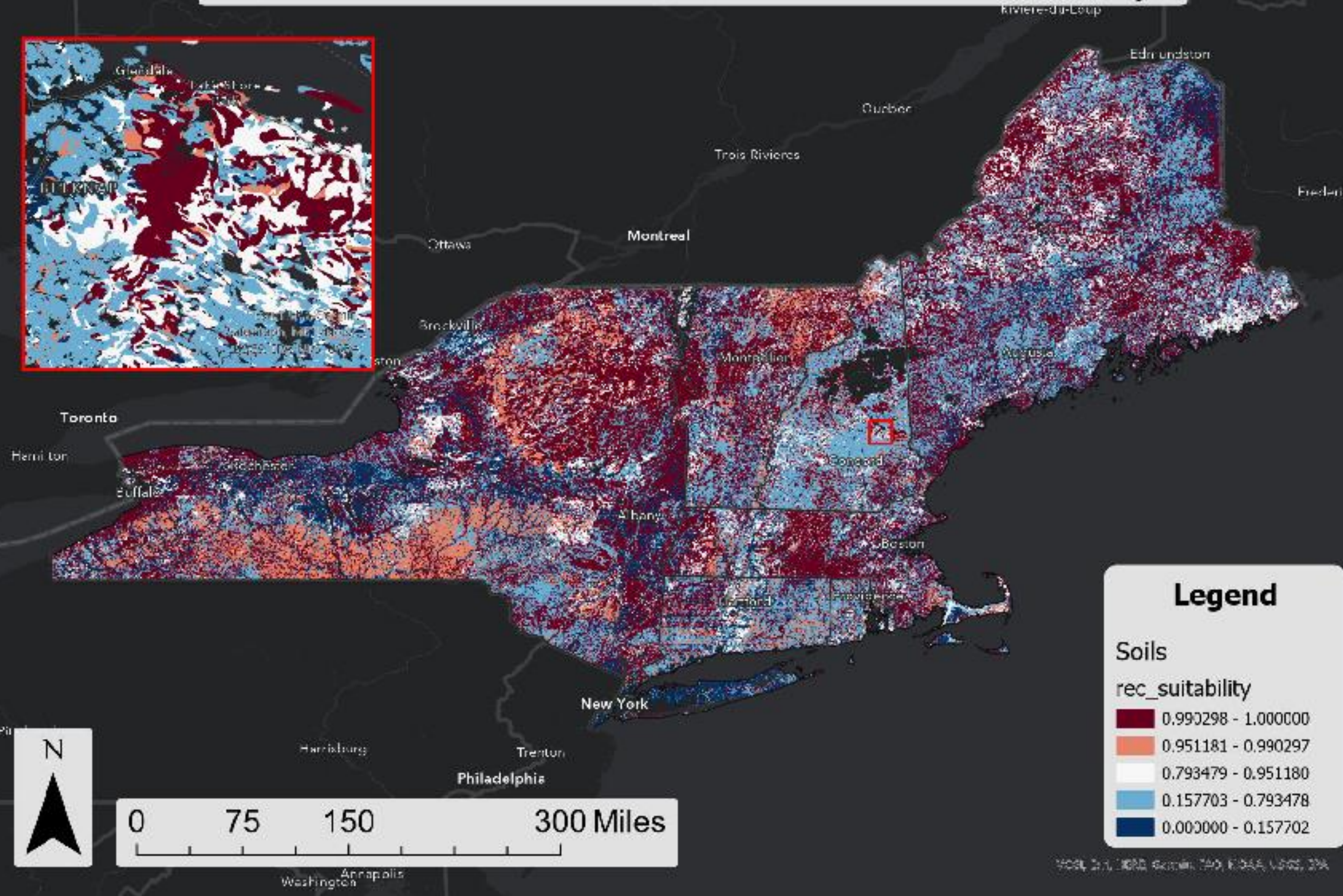


Forest Trail Use Per Capita

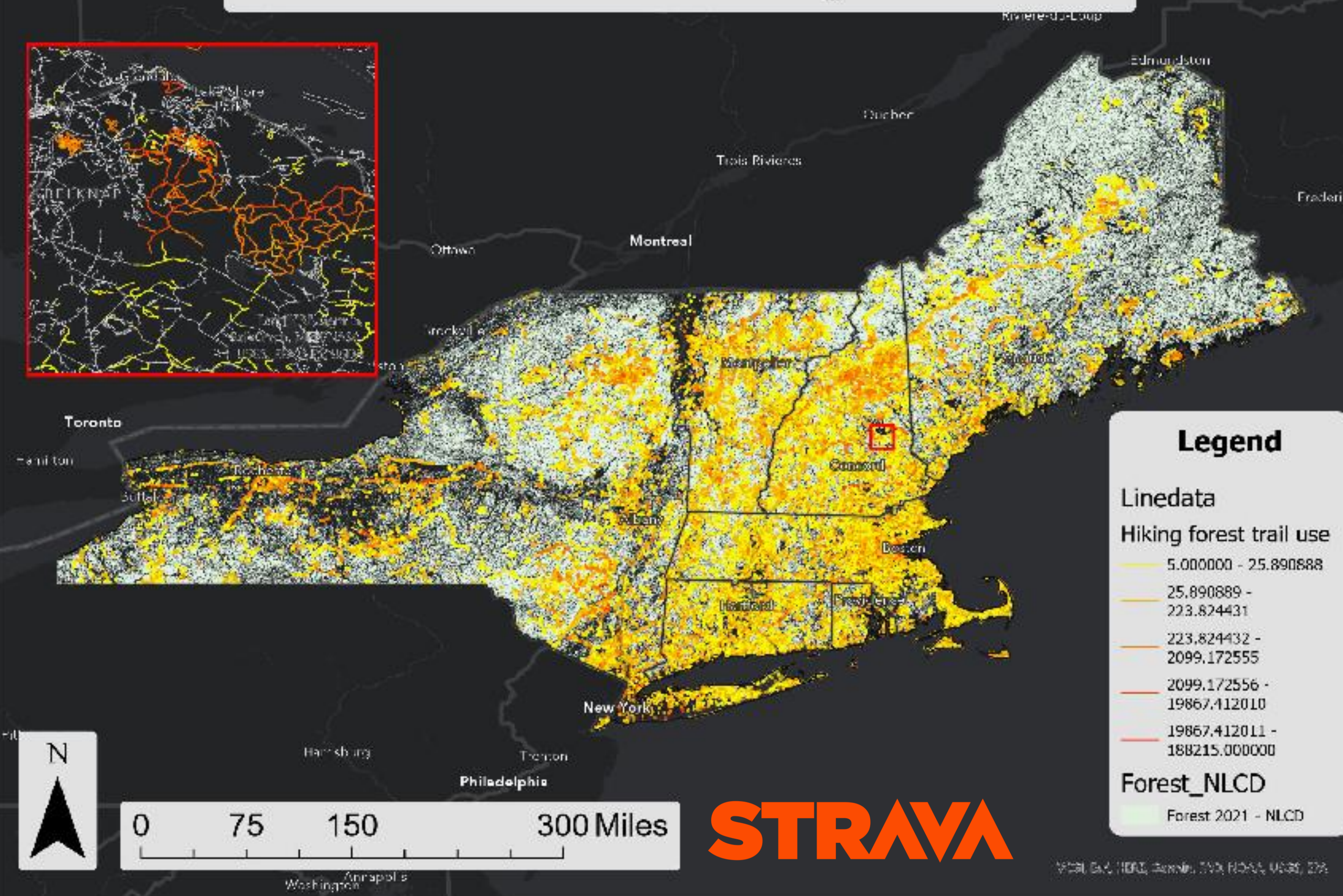


# Recreational Impact on Facets of Forest Health

## NRCS Forest Recreational Trail Suitability



## 2022 Strava Forest Hiking Trail Use



## State Specific Hiking and Biking Outliers

### Hike and Bike per Square Kilometer:

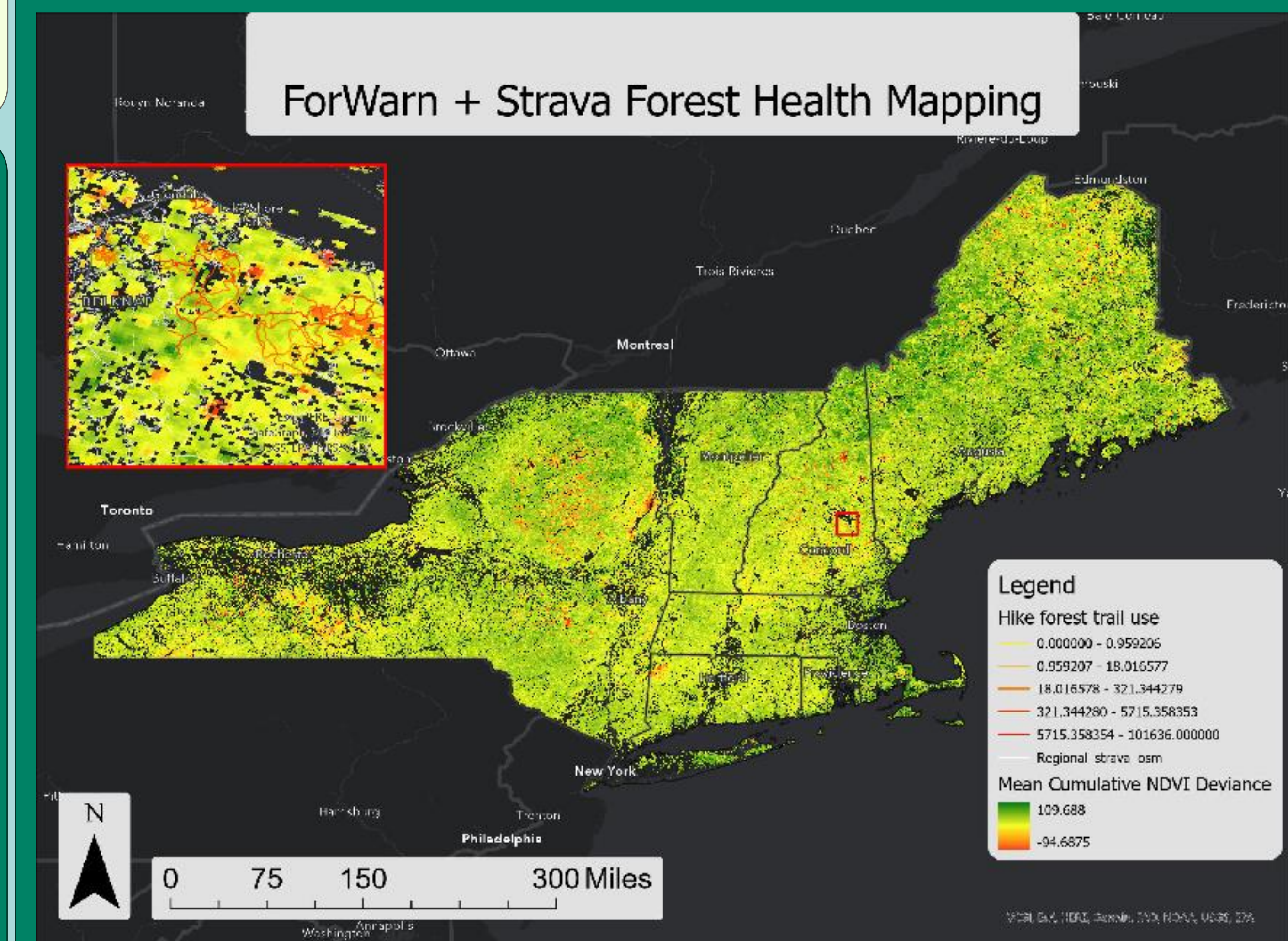
- Rhode Island (RI): High values may suggest that the state's compact size attracts both residents and tourists for recreational activities.
- New Hampshire (NH): The state's scenic landscapes and outdoor attractions likely contribute to higher engagement in recreational activities, appealing to both residents and tourists.

### Average Hike and Bike per Capita:

- Vermont (VT): High per capita values may indicate a strong outdoor culture, attracting both residents and tourists seeking recreational experiences.
- New Hampshire (NH): Similar to the per square kilometer analysis, NH stands out, suggesting a high level of recreational engagement among residents and potential tourists.

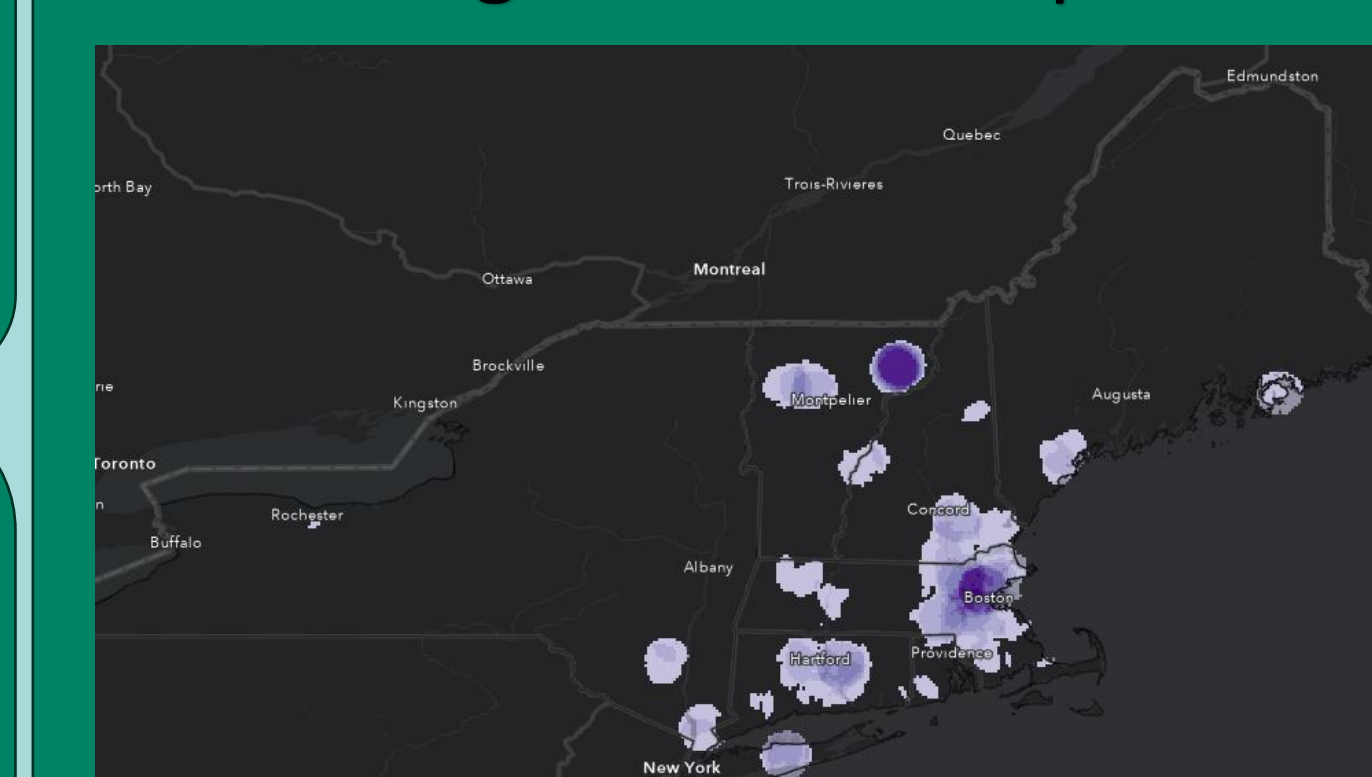
## ForWarn Composite Mean NDVI Deviance Health Proxy

### ForWarn + Strava Forest Health Mapping

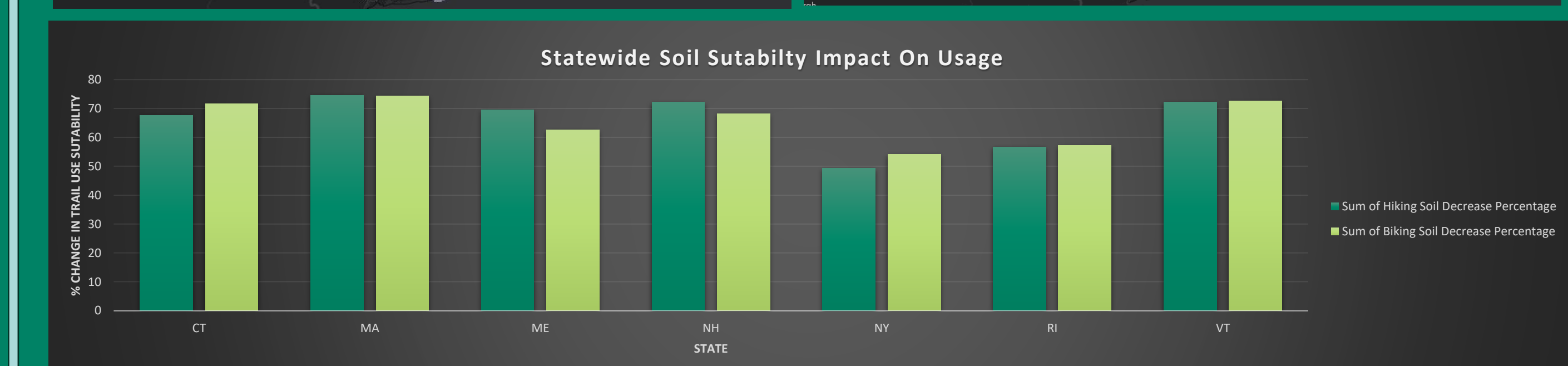
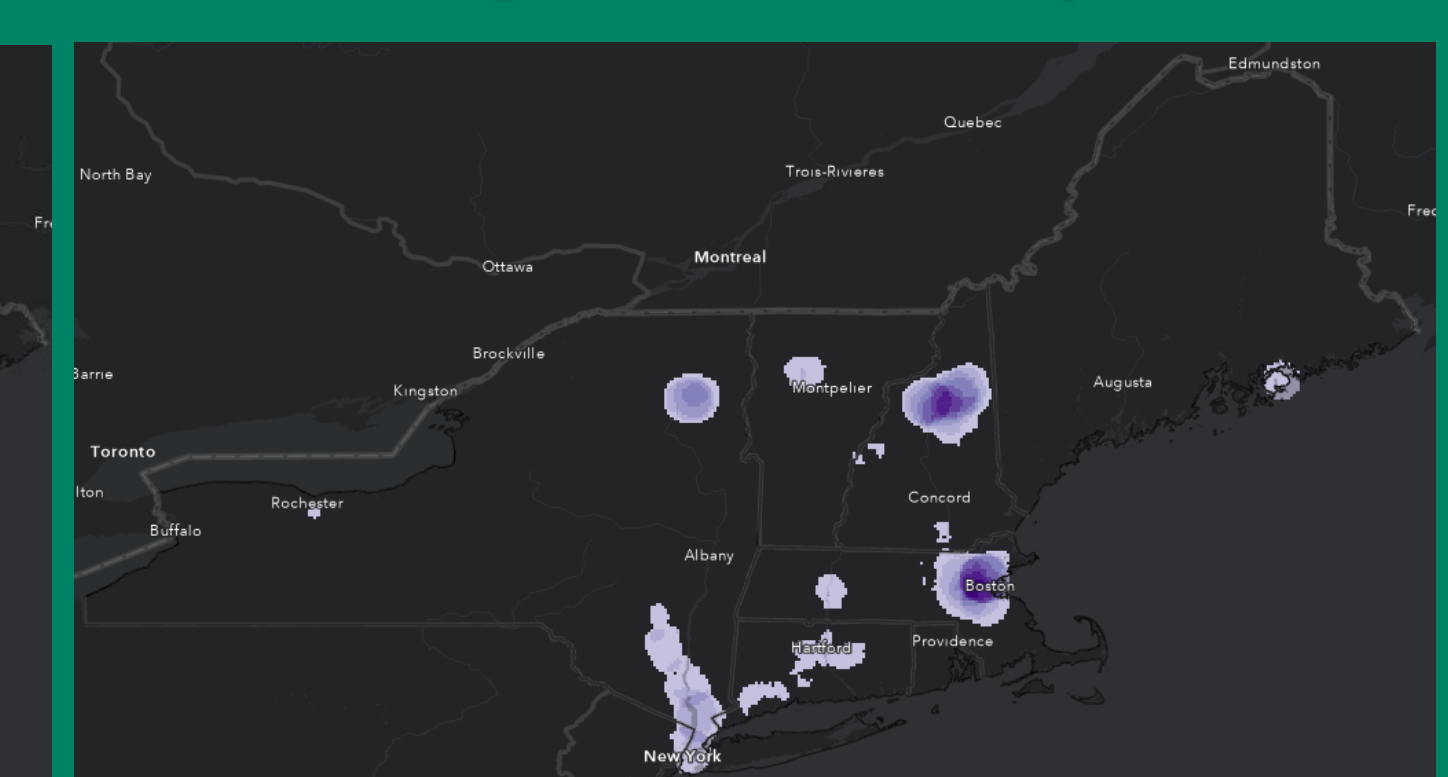


## Soil Use Hotspot Analysis

### Biking Soil Use Hotspots



### Hiking Soil Use Hotspots



### Soil Susceptibility:

- Geospatial data identifies certain forest soils as more susceptible to degradation due to recreation.
  - Biking – Vermont and Massachusetts where the states with the most use on the least suitable soils
  - Hiking – Massachusetts and New Hampshire were the states with the most hiking use on the least suitable soil s
- Enables targeted conservation efforts to address soil vulnerability and promote sustainable land management to mitigate soil impacts which may have direct effects on tree and vegetative health.

### Wildlife Disturbance (not enough room to display):

- Recreational activities lead to a significant reduction in the size of undisturbed parcels of forested land.
- Implications for biodiversity as wildlife habitats are impacted by human recreation.
- Geospatial products aid in prioritizing areas for wildlife conservation efforts.

## Summary

In conclusion, this project provided valuable insights into potential impacts of recreation on forest health, using a multi-faceted approach that combined remote sensing data, geospatial analysis, and wildlife disturbance assessments. The products created during the course of this project can inform decision-making and management strategies to ensure the preservation and sustainable use of forested landscapes, particularly by assisting land managers in identifying areas that are a priority for different management objectives. While the analysis utilized available data sources and remote sensing techniques, the lack of comprehensive field-based data presented a substantial limitation. Recognizing the importance of such data and addressing the challenges in collecting and standardizing it is essential for future research aiming to assess the impacts of recreational activities on soil, wildlife, and forest health more accurately.

## Acknowledgements & Authors

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