Mapping hemlock decline in the Southern Appalachians using high and moderate resolution imagery

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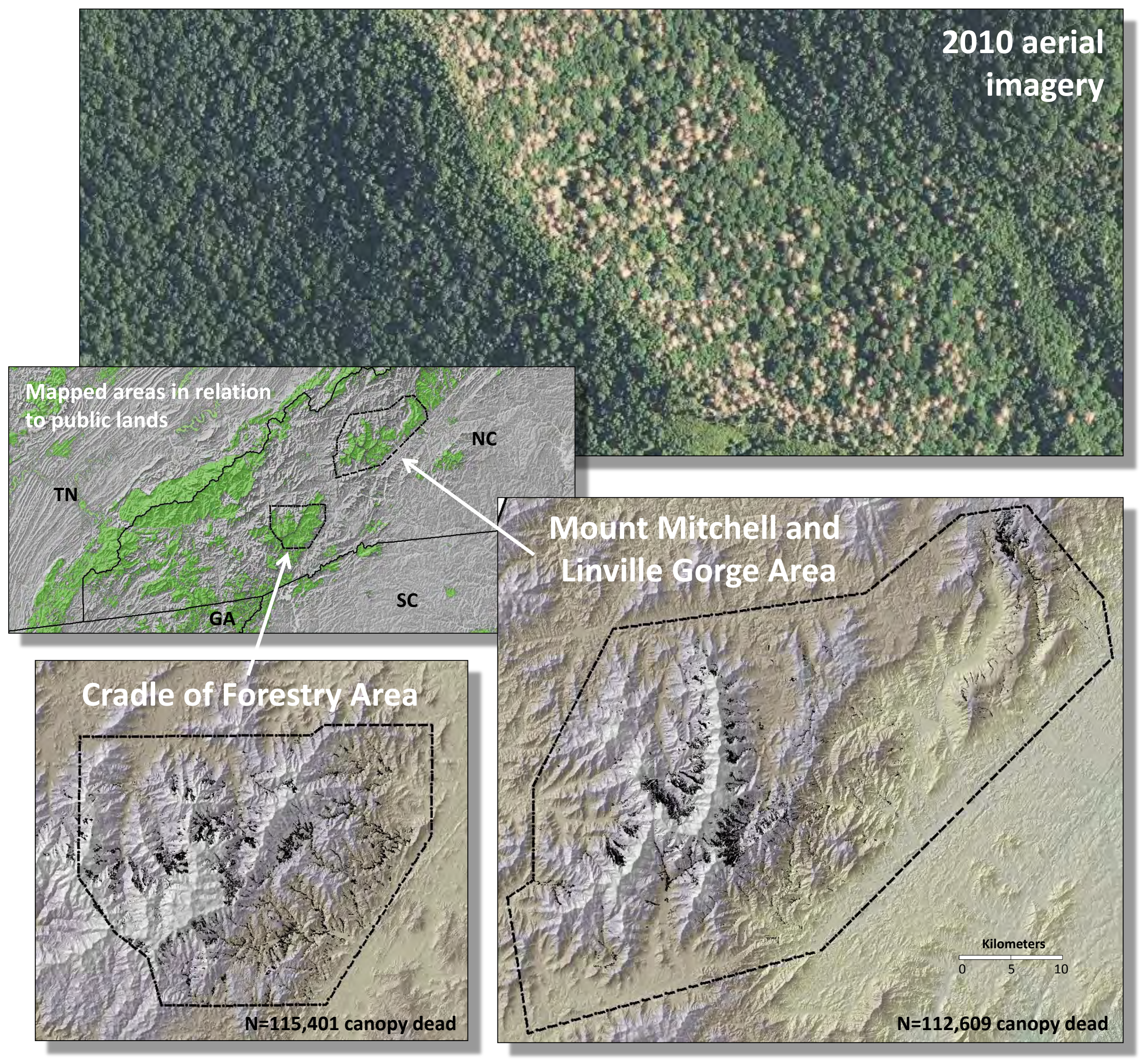
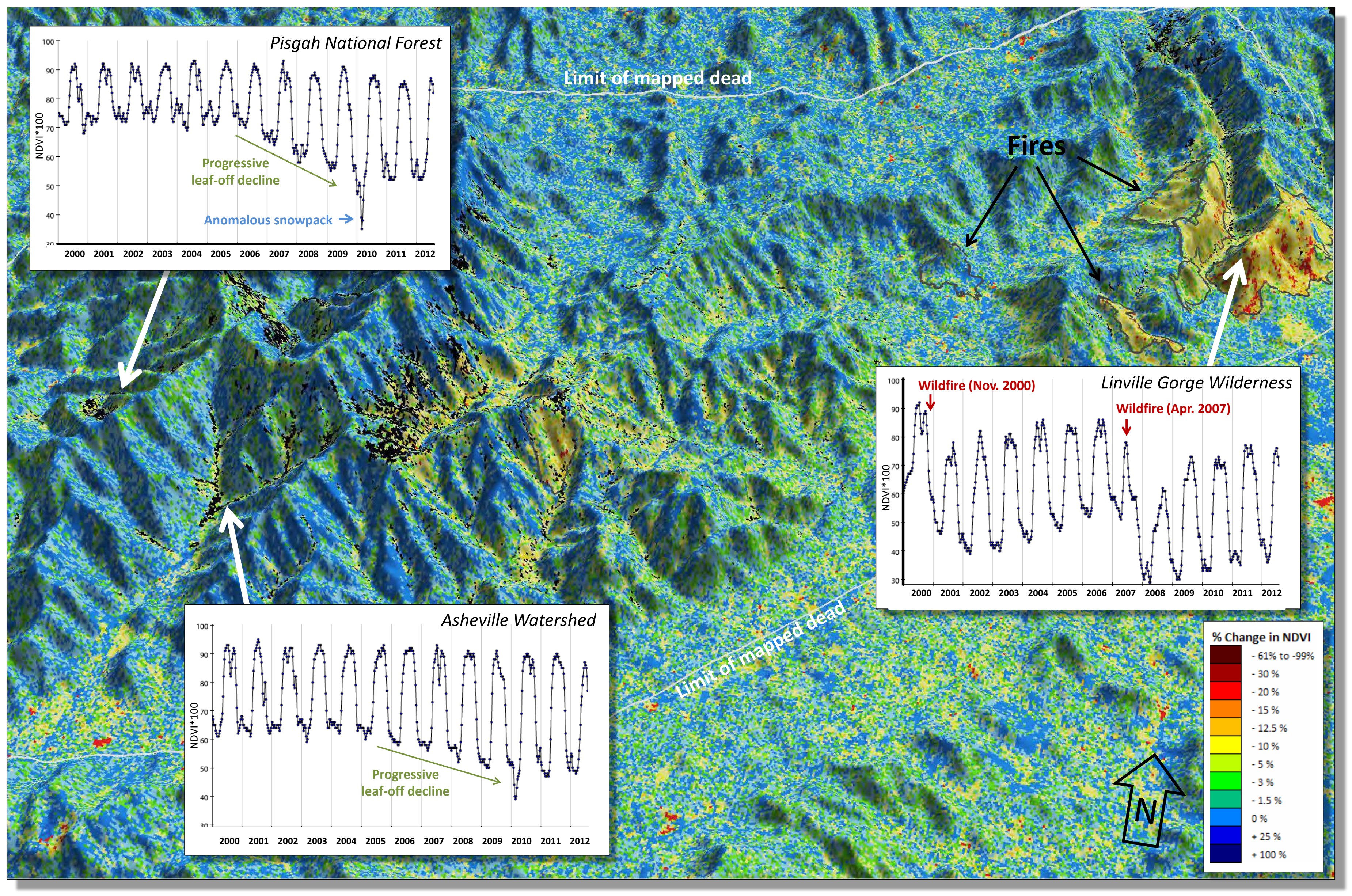
THE CHALLENGE

The non-native invasive hemlock woolly adelgid (*Adelges tsugae*) has killed hundreds of thousands of Eastern and Carolina hemlock (*Tsuga canadensis, T. caroliniana*) in the southern Appalachians in recent years. Eastern hemlock, in particular, is an important riparian species, as its evergreen boughs cool streams while providing resting and nesting cover for wildlife. Forest and wildlife managers need to understand where and how areas are affected, yet no cross-jurisdictional map of hemlock density or areas impacted exists. Maps that communicate the extent of mortality can help prioritize areas for remediation and restoration while providing novel insights into the niche of Eastern hemlock, a northern species, near the southern limit of its range.



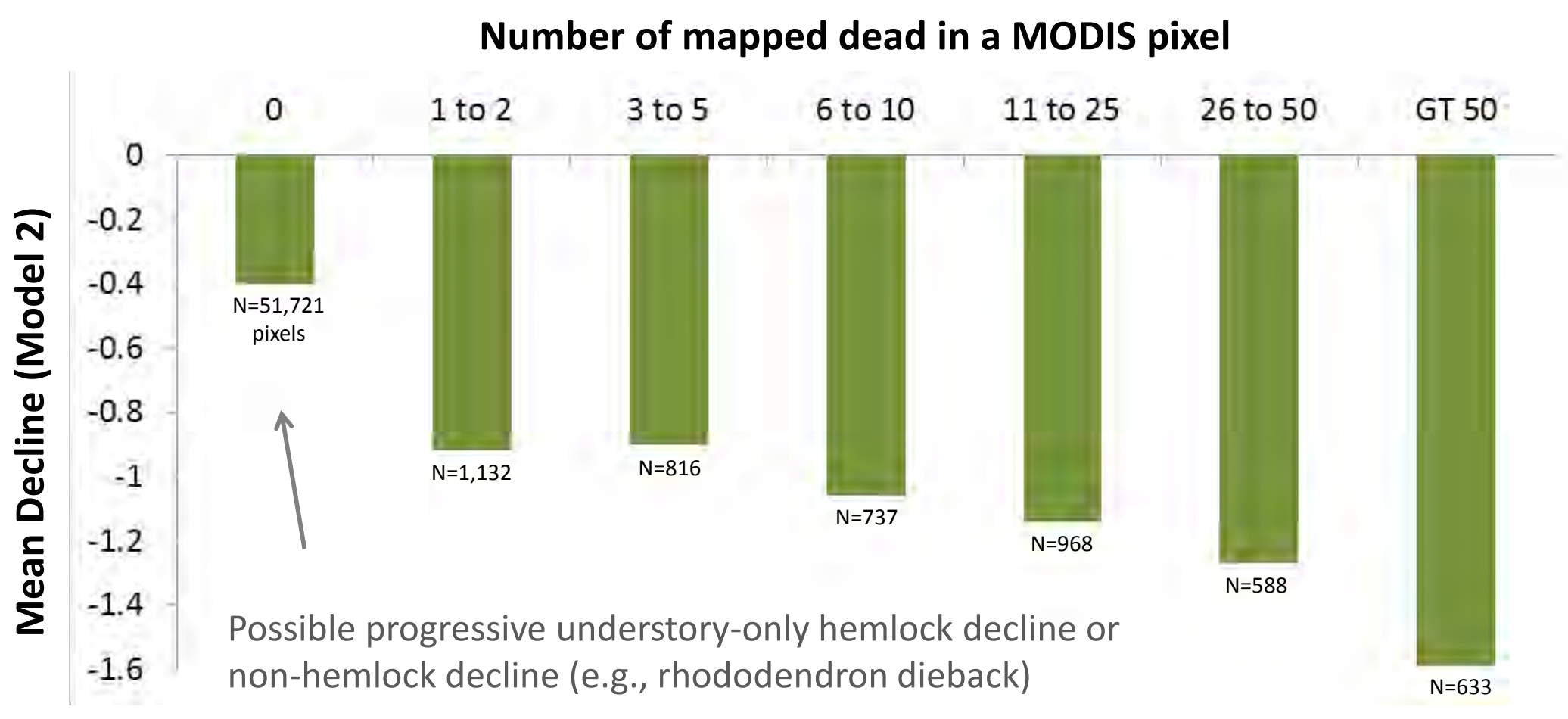


Background image shows the percent change in NDVI from Nov. 1999 to Nov. 2010 using 30m Landsat imagery. Black dots are photo-interpreted dead hemlock.

METHODS

Two focus areas in western NC were selected to calibrate and develop regional hemlock decline models. (Only graphs from the greater 1,600km² Mount Mitchell –Linville Gorge area are shown here). We digitized 112,609 visible canopy dead from enhanced summer 2010 NAIP aerial imagery (left) that are interpreted to be Eastern or Carolina hemlock based on their canopy structural attributes, known habitat and informal field observations. When necessary, leaf-off 1998 color infrared imagery was used to refine our interpretations that these are dead hemlock.

We used the MODIS-based *ForWarn* 8-day NDVI dataset (http://forwarn.forestthreats.org) to identify change in the 15th or 25th percentile of the fiscal year distribution. Alternate models were tested including the regressed slope of these percentiles (Model 1, 3) and progressive decline using a moving two-year mean of the 25th percentile (Model 2). Our use of percentiles and a two-year mean reduced the confounding effects of variable snowpack masking evergreen. Model 2 was designed to distinguish the progressive multi-year decline that is characteristic of hemlock woolly adelgid impacts from sudden evergreen decline that can result from fire or logging.

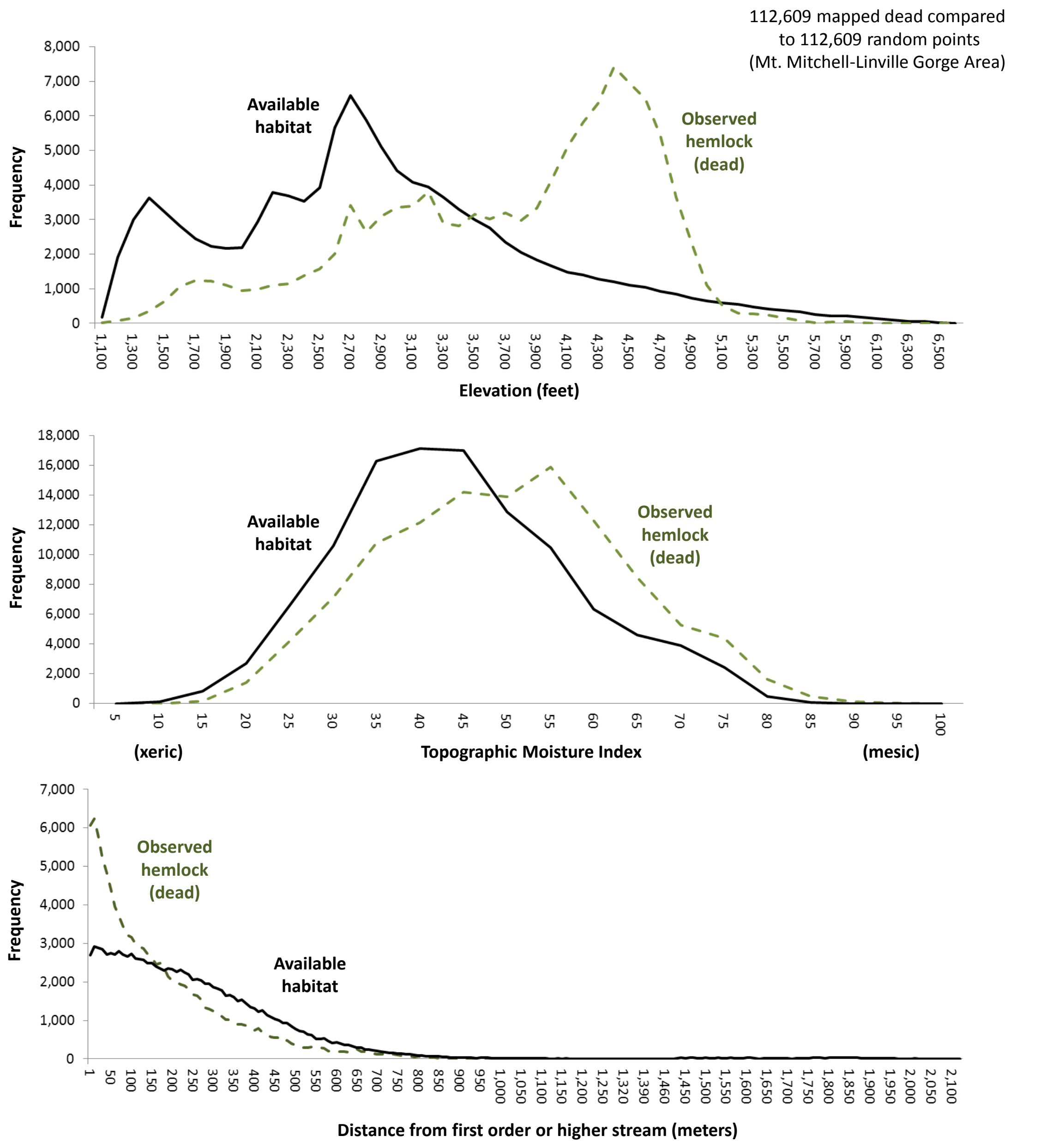


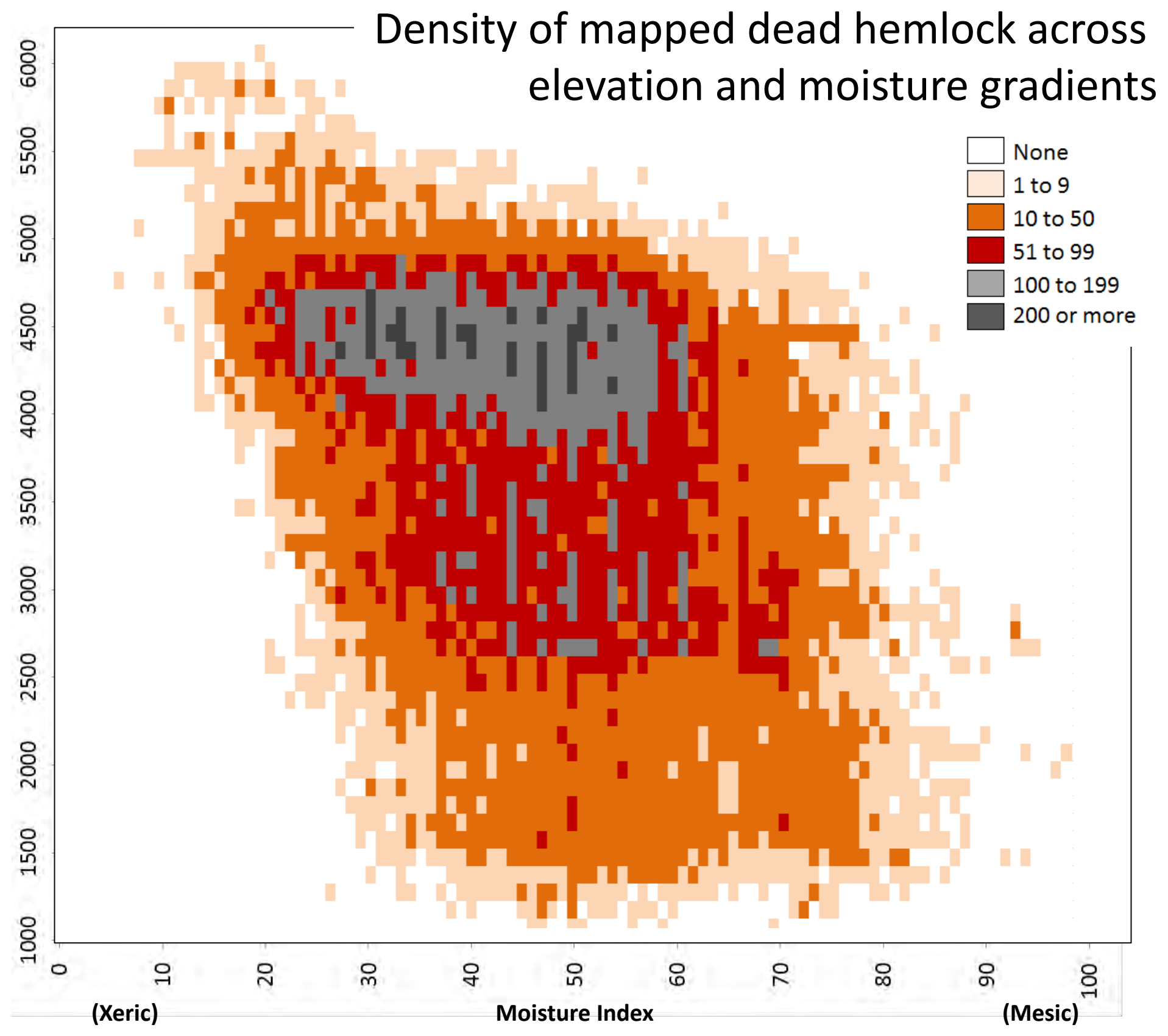
RESULTS: MODELING THE DISTRIBUTION AND SEVERITY OF HEMLOCK MORTALITY

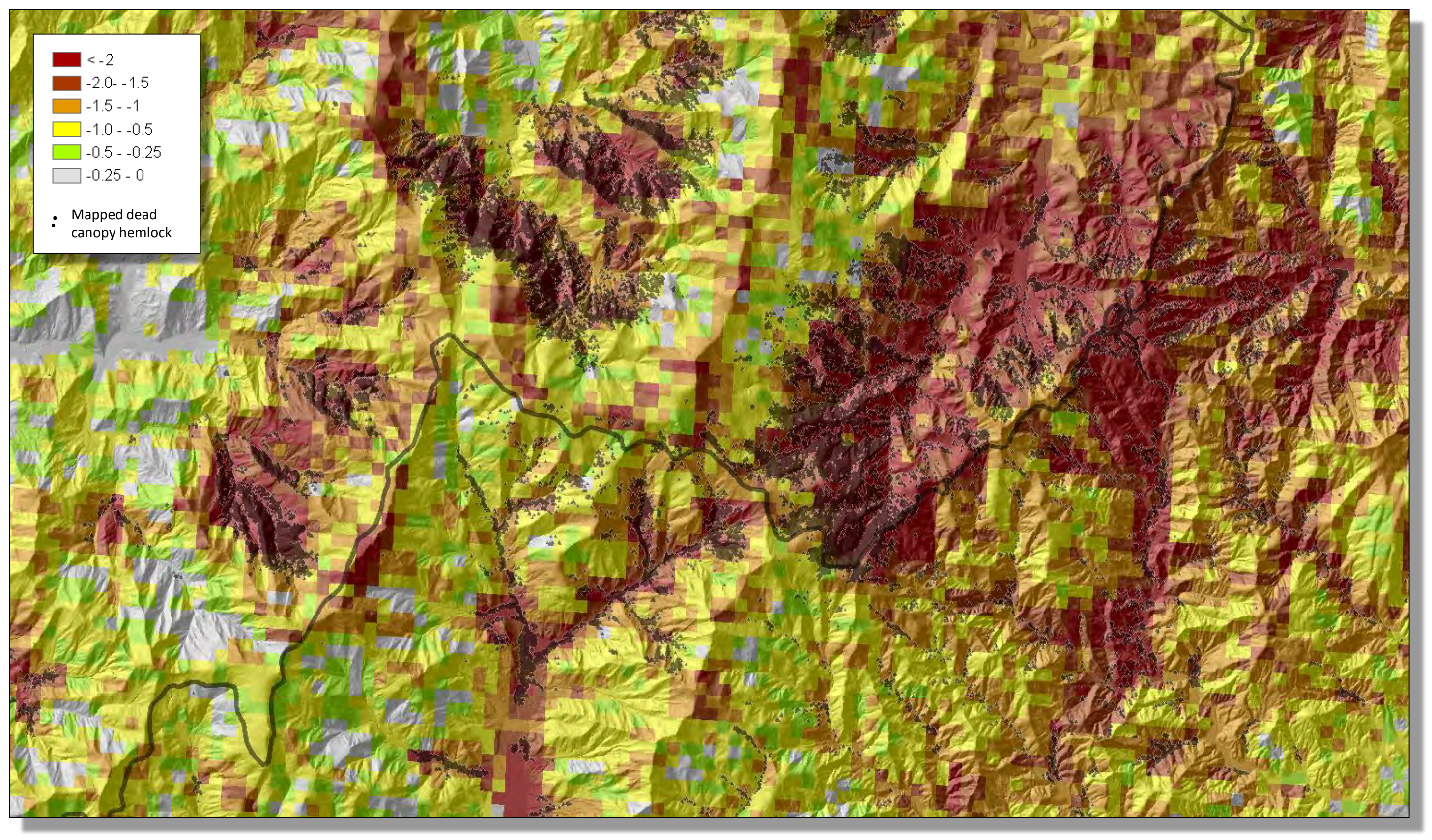
Maps showing change in evergreen vegetation based on slope (Models 1 and 3) provide insights into the condition of evergreen overstory and understory vegetation relative to all agents of change. Our progressive decline model (Model 2) successfully distinguished hemlock decline from burned areas better than models only based on the slope of decline, but we observe pixels with mapped canopy dead that we fail to detect in our model and pixels with no mapped canopy dead that show substantial progressive evergreen decline. This latter outcome may be caused by areas of dying understory hemlock that lacked overstory hemlock. Our MODIS based models and Landsat NDVI change (top center image) can distinguish this decline better than summer NAIP. If not from dying hemlock, this decline could be from progressive rhododendron dieback, although the extent of this phenomenon is unknown.

RESULTS: POST-MORTEM INSIGHTS INTO HEMLOCK HABITAT

Mapped canopy hemlock show a preference for higher elevations and wetter sites than what is available. Hemlock is most common between 2,500 and 5,000 feet, but hemlock prefer 4,000 to 5,000 foot elevations considerably more than a random distribution suggests. This high elevation habitat tends to be on mesic northern aspects, while hemlock is typically confined to the near-stream environment on southern slopes. Hemlock were absent from certain riparian areas, possibly due to disturbance legacies or competition from rhododendron.

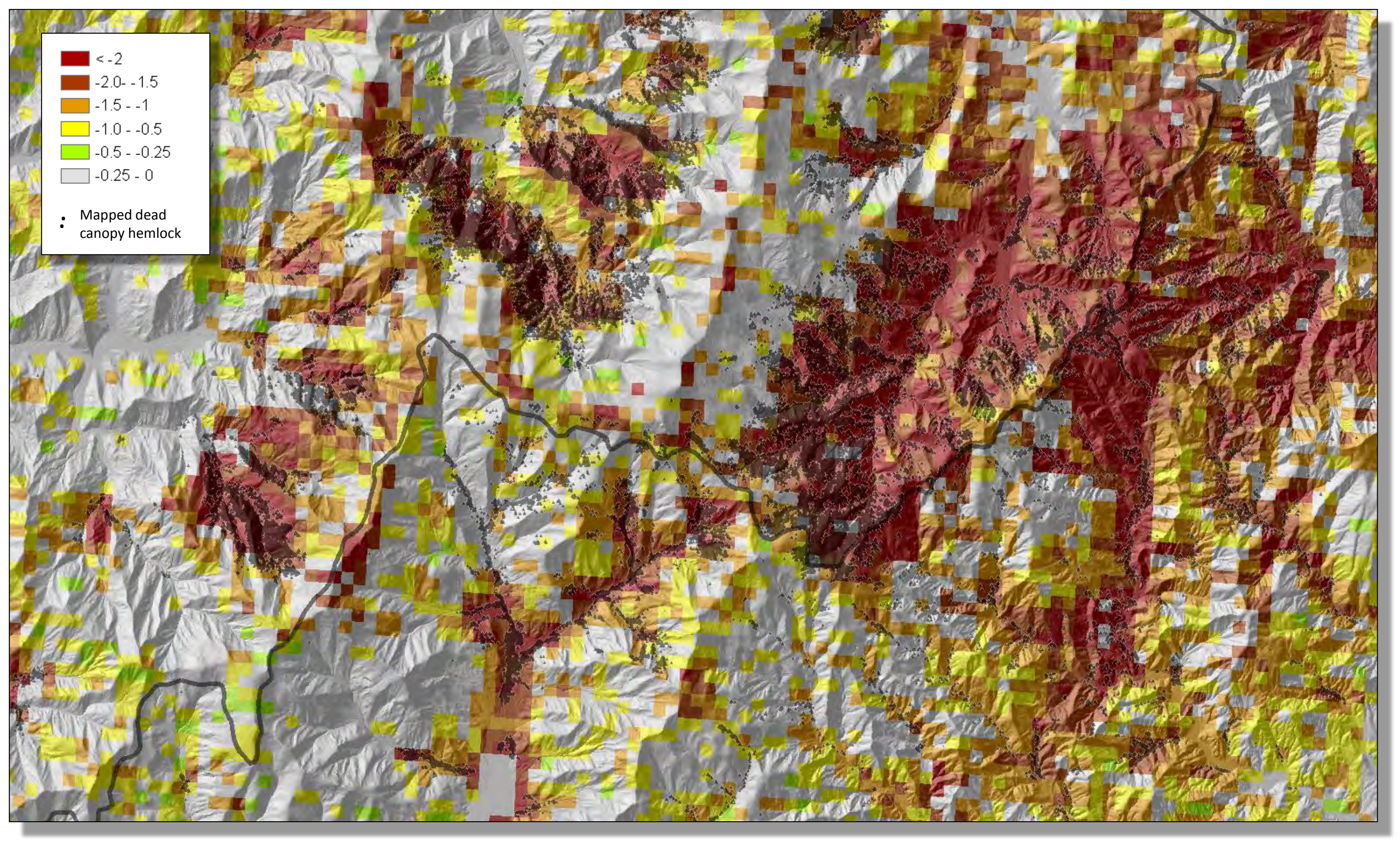

112,609 mapped dead compared to 112,609 random points (Mt. Mitchell-Linville Gorge Area)


Density of mapped dead hemlock across elevation and moisture gradients



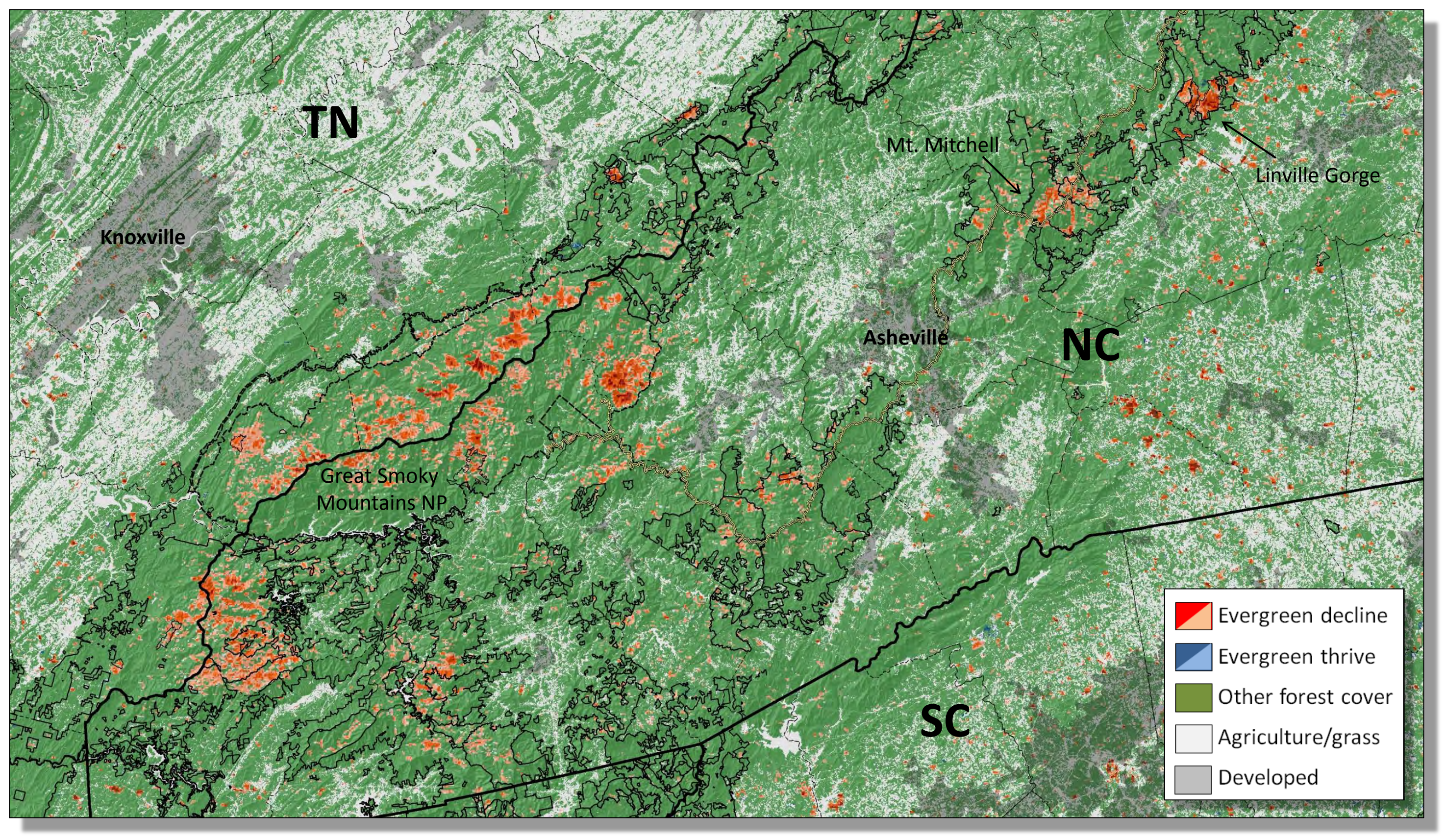
Evergreen Decline Model 1 for the Mt Mitchell area:

Slope of 25th percentile NDVI, 2006-11 (MODIS)



Evergreen Decline Model 2 for the Mt Mitchell area:

Slope where 2-yr mean of 25th %ile progressively drops, 2006-11 (MODIS)



Evergreen Decline Model 3 for the Southern Appalachians:

Slope of 15th percentile NDVI, 2001-10 (MODIS)