Addressing Hurricane Helene's Disturbance:
A Customized Mapping and Data Integration Solution by LANDFIRE

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QUICK SUMMARY: Hurricane Helene's landfall during the final days of the 2024 fiscal year challenged LANDFIRE to capture disturbances in time for the LF 2024 Preliminary Disturbance product. Just months after the hurricane, LANDFIRE responded with a targeted mapping effort, incorporating external data sources to ensure timely and accurate information in the LF 2024 release.

BACKGROUND: Hurricane Helene, a powerful Category 4 hurricane, made landfall in late September 2024 and delivered a catastrophic combination of torrential rainfall and destructive winds across the southeastern United States. The storm's impact was particularly severe in western North Carolina, East Tennessee, and southwestern Virginia, resulting in more than 245 fatalities, numerous injuries and widespread damage to vegetation, infrastructure, and ecosystems.

Hurricane Helene's widespread damage raised concerns among southern foresters that current vegetation and fuel conditions would not be reflected in the LF 2024 release. The storm's timing during Fiscal Year 2024 made it difficult for LANDFIRE to capture and incorporate disturbances from the hardest-hit areas in time for the LF 2024 Preliminary Disturbance (PDist) release. Without this, standard data update cycles would fail to reflect these landscape changes until the release of the LF 2025 PDist product, out in 2026. The need for timely and accurate data for the upcoming fire season and appropriate natural resource management activities

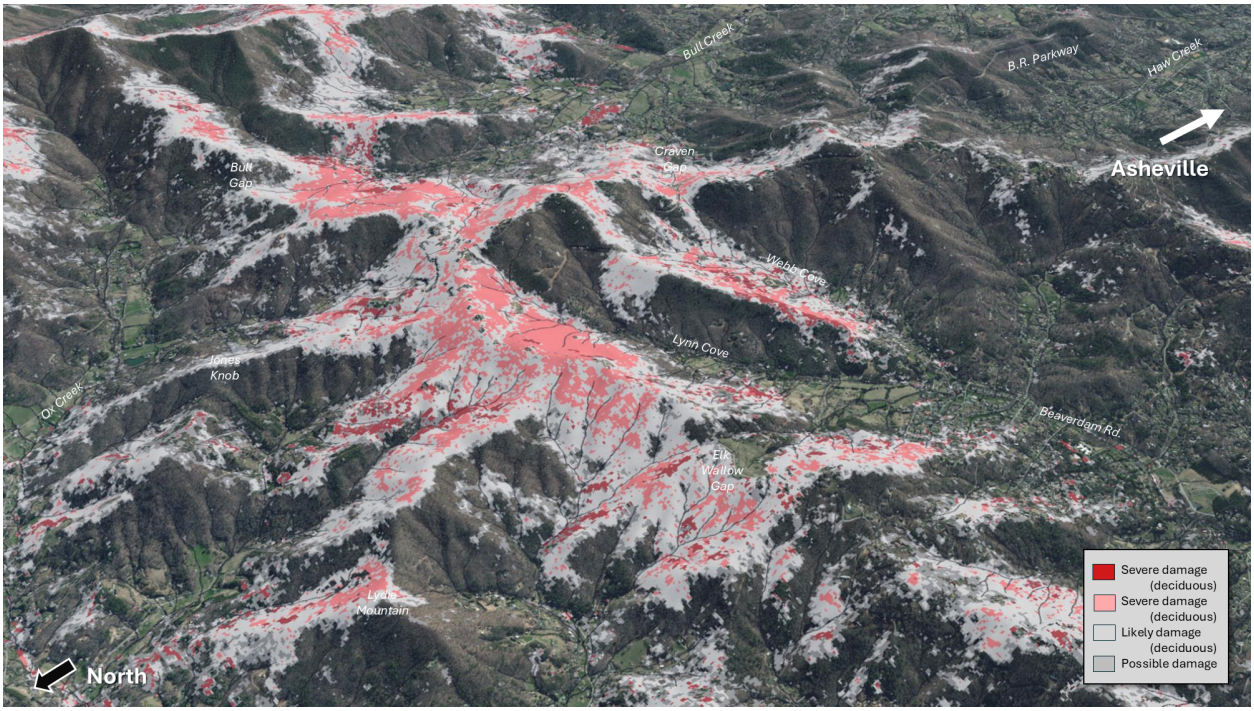
Blowdown from Hurricane Helene. Big Ivy area of the Pisgah National Forest. © Steve Norman.

necessitated a specialized mapping approach. This document outlines the process by which LANDFIRE incorporated disturbance data reflecting Hurricane Helene's impact in time for release with the LF 2024 PDist product.

THE HURRICANE HELENE CHALLENGE: Because LANDFIRE's standard annual disturbance mapping aligns with the federal fiscal year, image composites are derived from a range of dates concluding on September 30th. These composites are generated from stacks of cloud-masked Harmonized Landsat Sentinel (HLS) images, where percentile statistics (e.g., 15th, 50th, 90th) are calculated for each pixel across the selected images. This process aims to create a cloud-free, six-band composite image for change detection analysis. However, late fiscal-year disturbances, especially in the final seasonal composite, can be significantly underrepresented due to dominance by pre-disturbance conditions.

In short, if a disturbance is detected in an image on the first day of the date range for the composite, it will still be evident in all of the subsequent images in that composite's date range, strongly influencing the percentile statistics. Conversely, if a disturbance is detected on the final day, represented by only one image in the date range, it will have minimal impact and may be missed entirely.
Hurricane Helene presented a challenge to our LANDFIRE Team as the storm's impact occurred in the final days of the federal fiscal year and coincided with extensive cloud cover. Consequently, any imagery with disturbed areas collected in the final days of the fiscal year were likely masked out, preventing its inclusion in the standard fall composite. This resulted in an under-representation of the storm's significant disturbances in the fall composite. In response, LANDFIRE initiated a targeted mapping effort that enabled the detection and incorporation of these unique late fiscal-year disturbances into the LF 2024 PDist product.

DATA SELECTION & INTEGRATION: Faced with the challenge of incorporating a targeted mapping for Hurricane Helene while maintaining LANDFIRE'S typical annual production schedule, alternatives were explored. From late 2024 through January 2025, personal communication with southern foresters indicated that several data products, produced by US Forest Service Southern Research Station researchers Steve Norman and Bill Christie, were available. Consequently, LANDFIRE reviewed these datasets, which were derived from imagery captured by varying sensors at differing resolutions and locations. This review aimed to determine if existing data could be integrated, potentially avoiding the need for a separate, dedicated mapping effort. To assist in this evaluation, LANDFIRE produced specific post-hurricane image composites to help assess the alignment and accuracy of the datasets.



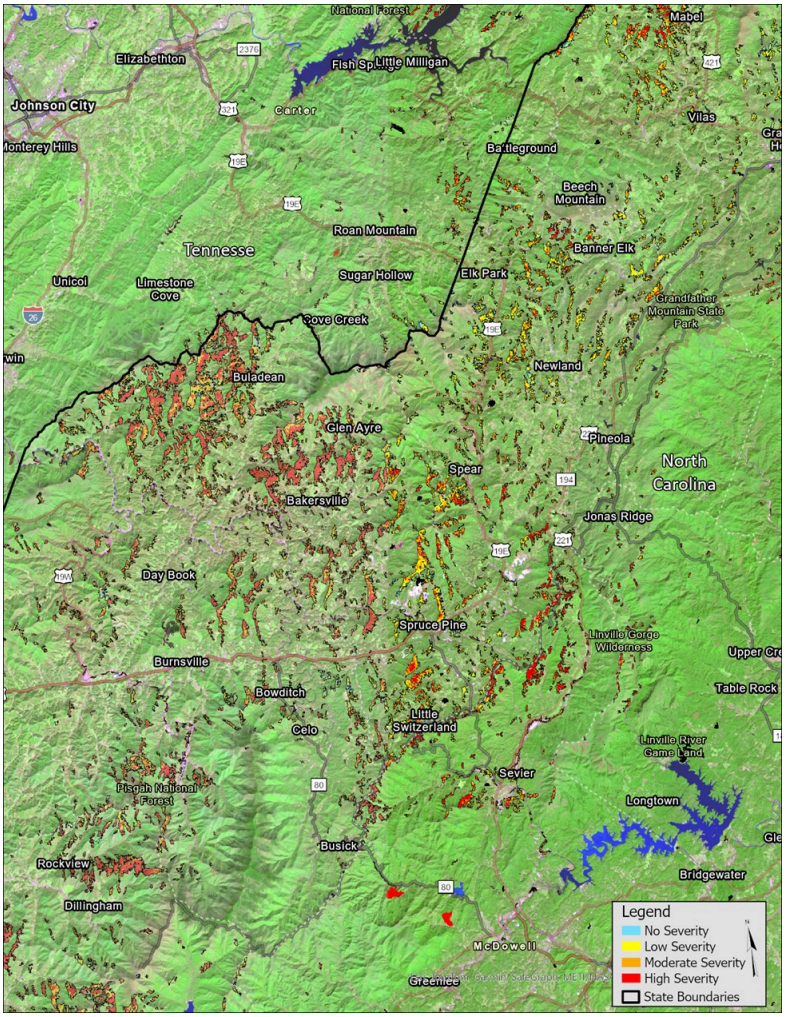
Elk Mountain Area, demonstrating significant forest change. Buncombe County, NC. © Steve Norman.

Ultimately, LANDFIRE decided to incorporate Steve Norman's HiForm Major Forest Damage Data (above), which covered the most severely impacted areas of the southern Appalachians, specifically western North Carolina, eastern Tennessee, extreme northeast Georgia, and southwestern Virginia. This decision was based on several factors: its high resolution (approximately 10m); its compatibility and accurate alignment with LANDFIRE's image composites; and unlike datasets from the Piedmont and coastal plains, the product received some level of field-verified quality assurance. Moreover, the local expertise in the dataset's creation, alongside collaborative information sharing, further validated the use of this dataset.

THE COASTAL PLAINS: The coastal plains were excluded from this mapping effort. This decision stemmed from the observation that the most severely impacted areas were predominately located within the lowlands surrounding rivers and water bodies. The available datasets overlapping these areas indicated high levels of change from what appeared to be short-term flooding, or perhaps leaf stripping, rather than long-lasting blowdown or severe tree damage.

Because LANDFIRE does not map flooding as a disturbance, and due to the difficulty in distinguishing pre-hurricane mechanical changes from post-hurricane damage in these areas, confidence in the data from this region was lower than desired and correctly assigning disturbance type would have necessitated significant additional effort. Accurate causality labeling of

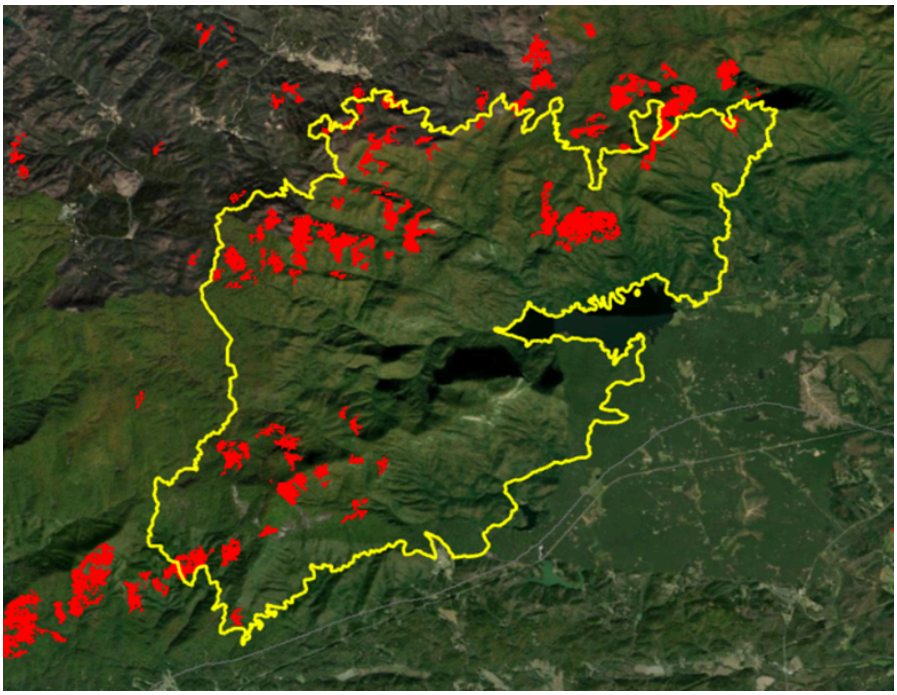
LANDFIRE disturbances is necessary in mapping the damage to fuels from Hurricane Helene. The assigned disturbance type significantly influences fuel model transitions/assignments. For example, a disturbance labeled as a ‘clearcut’ indicates complete vegetation removal, resulting in a fuel model reflecting minimal fuel. Conversely, a 'weather' event, such as a hurricane where trees are defoliated or blown down, adds fuel to the site, necessitating a different fuel model assignment. If LANDFIRE had used the standard 'Unknown' disturbance label for these satellite-detected changes, it would have implied vegetation removal, leading to incorrect fuel model assignments. Therefore, accurate disturbance type attribution for each disturbed pixel requires careful attention to ensure fuel models (and subsequent fuel loads) have been properly assigned.



Map representing the areas of significant damage identified by HiForm, which have been adjusted to align with LANDFIRE's standards.

RESULTS: The integration of the HiForm Major Forest Damage Data yielded results that were observationally consistent with LANDFIRE’s independent post-hurricane image composites and change detection products. Despite the absence of formal quality assurance procedures, the processed data displayed a noteworthy level of spatial alignment and agreement with these independently derived datasets. This consistency provides evidence of the data's suitability and the effectiveness of the processing steps in reflecting Hurricane Helene's damage. The graphic above illustrates the extent of significant damage mapped by HiForm as rendered compatible with LANDFIRE's standards.

Recent extensive wildfires in the Southern Appalachian region, such as the Table Rock fire above (showing the Integrated



Red represents the area that LANDFIRE mapped as severe hurricane damage from Hurricane Helene (based on the HiForm inputs and LANDFIRE's standardized severity process). The yellow represents outline of the Table Rock fire.

Reporting of Wildland Fire Information, IRWIN, perimeter 13,845 acres as of April 2nd, 2025), show that the hurricane damage mapped as severe by LANDFIRE overlaps some of the areas burned in the wildfire. Determining the effect of hurricane damage on fire behavior and severity in different ecosystems is one way to utilize this type of data.

CONCLUSIONS: Hurricane Helene presented a unique challenge to LANDFIRE's standard disturbance mapping processes. Through a targeted mapping effort that utilized external, regionally developed data sources and refined procedures, LANDFIRE successfully incorporated the storm's most damaged forested areas into the LF 2024 PDist product release. This addressed the concerns of southern foresters and provided updated information for wildfire risk assessments, highlighting the urgent need for fuels data, especially after a disturbance affecting such a large region. Although LANDFIRE took significant steps to assess and map the hurricane damage as an additional workflow to normal production schedules, more resources would typically be needed to release late fall disturbances and fuel changes by spring, without a significant degradation in the quality of LANDFIRE products. Nevertheless, LANDFIRE's commitment to responsiveness and adaptability aims to enhance the value and reliability of its data and products whenever possible.

Got Questions?
Ask the LANDFIRE Helpdesk:
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