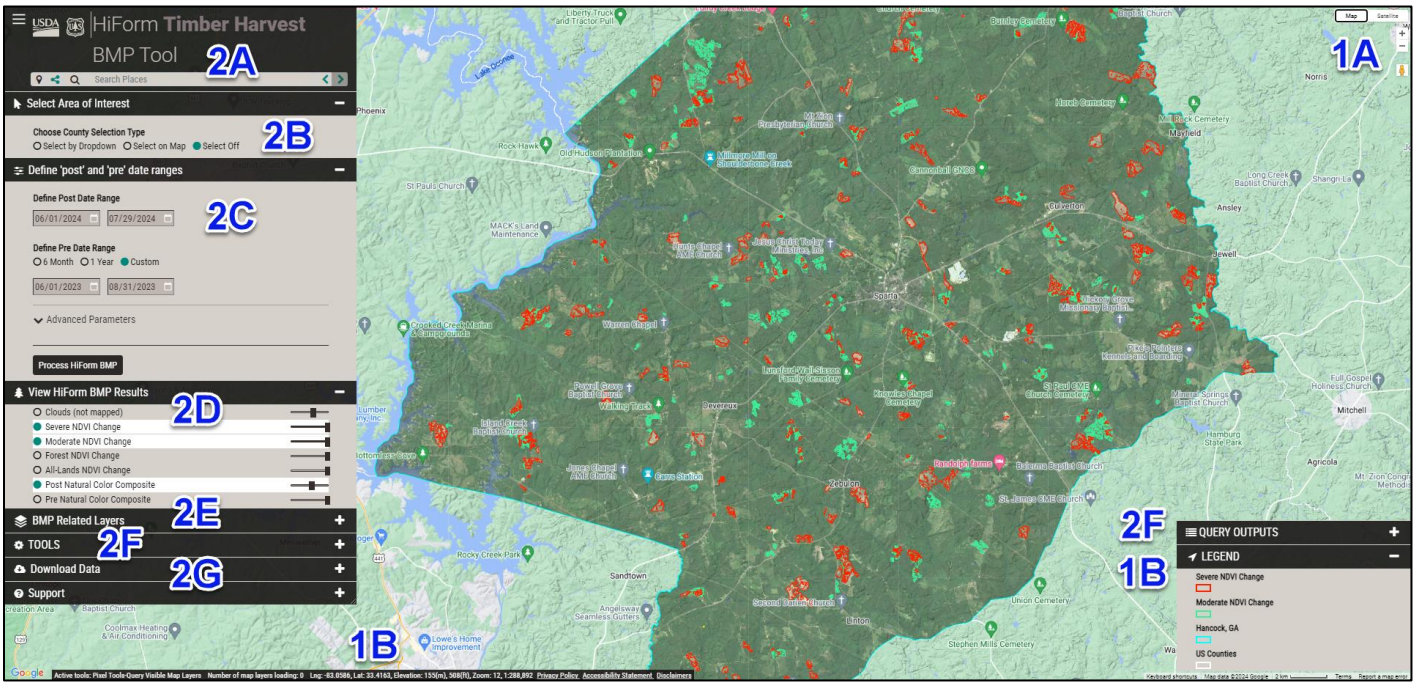
# The ***HiForm*** Timber Harvest BMP Tool *(link)*




## Introduction

This guide provides an overview for navigating the interface, and optionally downloading data produced by the USFS Southern Research Station's "***HiForm*** Timber Harvest BMP Tool". The intent of this application is to identify timber harvest sites, and other less severe silvicultural activities that may affect water resources. Agencies responsible for monitoring the implementation of water-related 'Best Management Practices' (BMP) can use this tool to assist in locating timber harvest sites and other silvicultural operations for the purpose BMP compliance.

The tool leverages the advantages and power of (1) cloud-based satellite image processing, (2) novel techniques to isolate these features of interest, and (3) an intuitive application interface to create, query, view and download results.

- *10m satellite imagery every 5-days*
- *Image compositing algorithm helps reduce cloud and cloud shadows*
- *Employs the latest in cloud masking technology*
- *Forest-only change is segmented into two levels of decline severity*
- *Mapping results are regulated by patch size*
- *Query the screen for information*
- *Share and document specific mapping scenarios and results*
- *Export findings in different formats*

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## 1. NAVIGATION AND INFORMATION RETRIEVAL

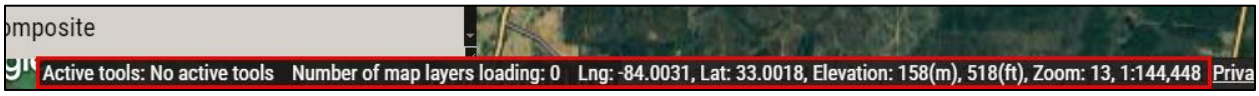
### A. General Navigation and the Application Programming Interface (API)

The controls at the upper-right portion of the browser window regard selecting an image or map basemap. Map view has a checkbox drop-down option to turn terrain view on and off. Satellite view has a checkbox drop-down option to turn labels on and off. Below the full screen button are zoom tools for viewing the map at different scales.

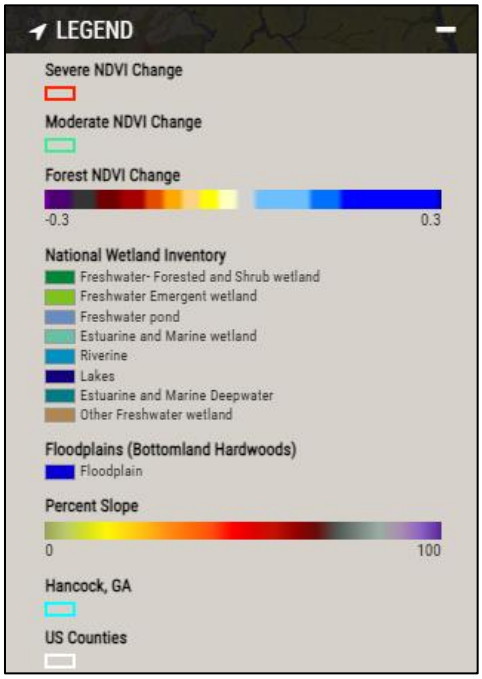

Zooming 'in' and 'out' can also be accomplished using the scroll wheel on your mouse, or with the +/- controls. The orange "Pegman" icon allows you to move into Google Map Street View', if available. You can click and drag the person onto the map area. Any area that becomes highlighted in blue is available for you to drop the person to see ground-level imagery in that area. To exit street view, click the left-pointing arrow in the upper left corner of the window.

### B. Viewer Information Ribbon, Legend and Query Outputs

For additional information on a tool or layer, hover the mouse over the name and additional text will appear (if available). Navigate to the ribbon of text along the bottom margin of the viewer. The information bar contains presents the number of active tools, the number of maps loading, longitude, latitude and elevation of the mouse location, zoom level and map scale.

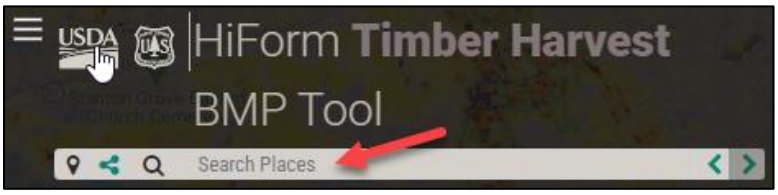



The **LEGEND** (bottom-right) presented information about the layers displayed. By default, the two levels forest disturbance are displayed, they relate to the relative severity of forest Normalized Difference Vegetation Index (NDVI) change. The red polygon outlines denote severe forest NDVI decline (-0.2 and worse) and generally associated with timber harvests. Green polygon outline denotes less severe forest NDVI decline
(-0.07 to -0.19) and can be associated with more moderate forest decline due to silvicultural thinning, or even partially re-vegetated timber harvest sites.



## 2. PERFORMING A CHANGE ANALYSIS

### A. Search Places

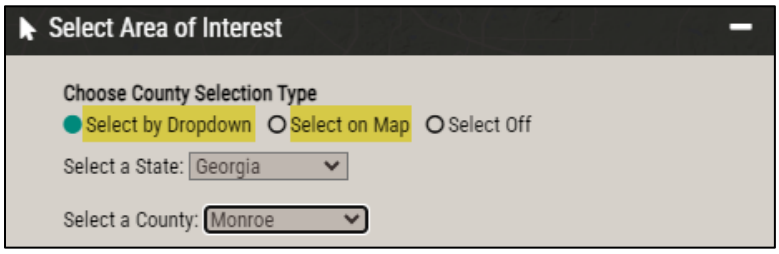



OPTIONAL: Use this text-entry-box to search and navigate to a geographic name, suggestions for a match will appear as you type, selecting one will execute a zoom to that location.

 - "*Click to share your current view*", once a change analysis has been performed, select this 'share-URL' icon to update the browser's URL for copying and sharing, or to save it for locally for documenting the results of your mapping scenario.

 - "*Click to go forward or back*", returns you to a previous extent.

### B. Select and Area of Interest



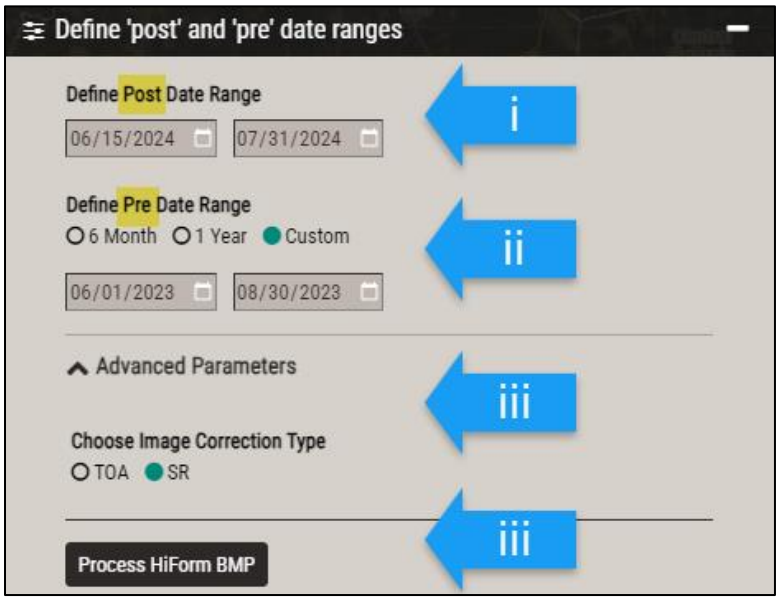

The current version of the ***HiForm*** Timber Harvest BMP Tool performs an NDVI change analysis for a single county at a time. There are two options available to select a county for mapping, via the "Select by Dropdown (selection by State and County), or by navigating the map to you area of interest and "Select on Map" by using the mouse on the map interface. In either case, once a county is selected its outline will be highlighted on the display in the color cyan.

### C. Define 'post' and 'pre' date ranges

Regarding date selection and phenological timing:

- Avoid mapping NDVI change during spring green-up or fall brown-down, you may be mapping the change in phenological timing from one year's season to the next
- For the 'pre', consider using a broad range of dates, this will produce a cloud-free-as-possible baseline image that will be used to calculate change
- Compare similar seasons: traditionally, summer to summer to capture growing season change, winter to winter can be used to isolate evergreen-only change
- For a winter NDVI change analysis, choose dates near the end of winter to reduce mapping the effects of low sun angle

- A hybrid approach, use a broad date range for the pre, and use a 'single date' of cloud free for the post (explore using the 'EO Browser' to locate a 'post' cloud free date)




i. *'Define Post Date Range'* - In this typical 1yr NDVI change analysis, notice I am choosing a 'post' period that encompasses 6-weeks before my current date.

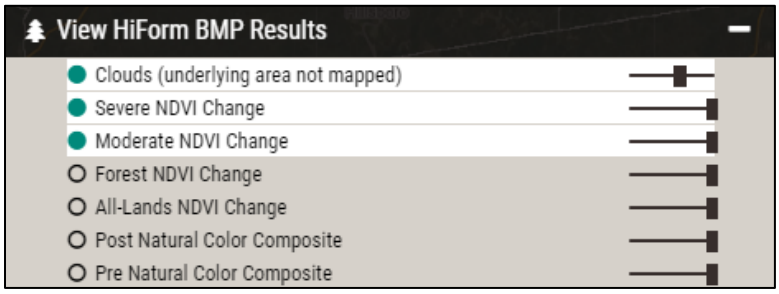
ii. *'Define Pre Date Range'* - When defining the 'pre' date range, notice I have chosen a "Custom" date range where I desire to create a cloud free-as-possible image by compositing multiple dates (into a single image) from all available Sentinel-2 images over the previous years' entire growing season. Compositing multiple images into a single image allows one to remove the negative influence of clouds. The 'pre' composite is created by max-NDVI-value compositing, taking the 'greenest' pixel (highest NDVI value) across all image dates (in the date range). The algorithm then composites all the highest value pixels into a single multi-date image. It is the composited image that that is used in the change analysis.

iii. *'Advanced Parameters: Choosing an image correction type*,' the default image correction type has been set to SR, for "Surface Reflectance". SR image corrections can over-correct pixel values for clouds and cloud shadows which can create artifacts in imagery. Those pixel over corrections that can make its way into the NDVI change which can be undesirable. To mitigate these potential effects, we have used advanced cloud masking algorithms to create a "Clouds" layer (look in the BMP Results tab). The cloud masking routine identifies potential cloud contamination and removes those cloudy areas form the analysis, reducing the potential for errors of commission (denoting false NDVI change).

The other option is 'Top-of-Atmosphere'. TOA contains less post-processing and can contain fewer over-corrections than exhibited with SR. When an analysis is run, one can view the "Clouds" layer to see where the cloudy portions of the pre and post are located (if exists). If a narrow date range contain too many clouds, expand the limited date range to include more opportunities for cloud free accessions. We have attempted to mitigate the negative effects of clouds by creating a "Clouds" layer (look in the BMP Results tab). The "Clouds" layer identifies regions of the imagery that have been removed from the analysis and results.

iv. *'Process HiForm BMP'* - When the pre-, post-disturbance dates and correction-type selections are made, select this control to perform the NDVI analysis which outputs the two levels of forest NDVI change. Those two levels of forest NDVI change relate to NDVI decline severity which can then be generally attributed to specific types of silviculture treatments.

D. **View HiForm BMP Results**




View these layers and use your image interpretation skills to vet and interpret results. Sliders at the right of each layer can be used to adjust transparency of that layer.

**Clouds (underlying areas not mapped)** - If clouds are present in the pre and/or post images, they will appear as semi-transparent black (on top of other layers). The mapping of forest change is not performed for areas underlying cloud cover. If clouds are a problem, expand your pre- and/or post-date ranges to include more dates for the opportunity of more cloud free days.

**Severe NDVI Change** – Polygon shapefile representing thresholded NDVI change values greater than or equal to -0.20 and worse decline with a patch size greater than or equal to 1 hectare.

**Moderate NDVI Change** – Polygon shapefile representing thresholded NDVI change values -0.07 to -0.19 with a patch size greater than or equal to 2 hectares.

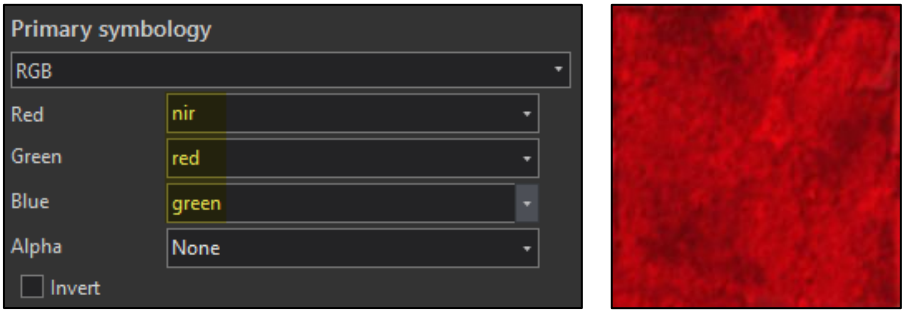
**Forest NDVI Change** – a forest-masked 10m raster with values representing absolute NDVI change. The forest mask is defined using 4-classes from 2021 NLCD dataset.

**All-Lands NDVI Change** – a water-masked 10m raster with values representing absolute NDVI change for all land cover types and land cover uses.

**Post Natural Color Composite** – The post disturbance image used to calculate NDVI change. View this product for the presence of clouds and non-target commission errors.

OPTIONAL '*COLOR INFRA-RED*' (CIR) DISPLAY: Regarding a downloaded 'Post Image Composite', an additional band has been included to facilitate changing the default display from a natural color. When the image is first brought in ArcMap or ArcGIS Pro for display, a 'post true color composite' will automatically be rendered with the default band order as shown below:


If you prefer to view the 'Post Composite' image rendered as a CIR (shown below), re-order the RGB band order as shown, with ESRI band Red = "nir" (near-infra-red), ESRI band Green = "red", and ESRI band Blue = "green" (highlighted below). If needed, further enhance via a stretch in symbology:




Caveats regarding date selection and phenological timing:

- Avoid mapping NDVI change during spring green-up and fall brown-down, you may be mapping the change in phenological timing from one season to the next (due to the annual variation in the start/stop of spring/fall).

- Compare similar seasons, winter to winter for evergreen-only change, summer to summer to capture growing season change

- When creating pre-disturbance baselines, consider using a broad (sometime multi-year) range of dates that will produce a cloud-free-as-possible baseline image that will be used to calculate change from the predate

- For a winter NDVI change analysis, choose dates near the end of winter to reduce mapping the effects of low sun angle

- A hybrid approach, use a 'date range' composite for the pre, and use a 'single date' of cloud free for the post (explore using the 'EO Browser' to locate a 'post' cloud free date

## E. **BMP Related Layers**

These layers are provided to assist the user in assessing the potential for water related issues:

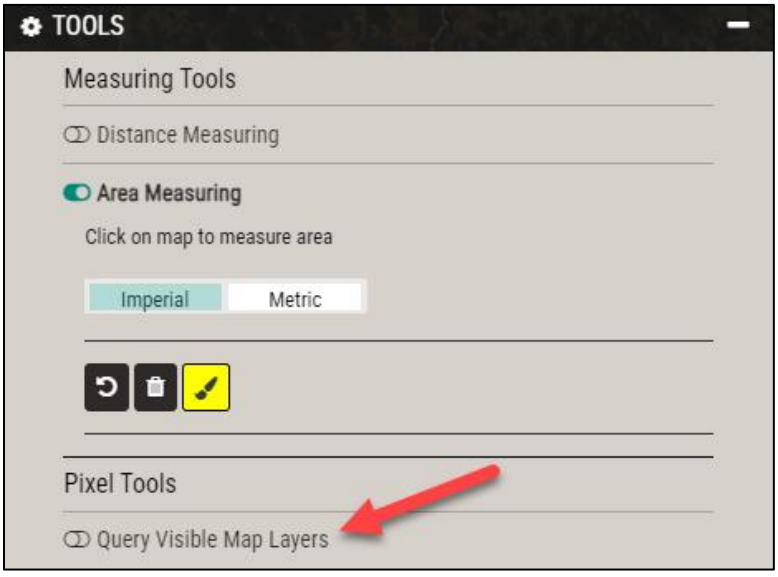
- "National Wetland Inventory" (NWI) layer is served by the USFWS, we have no control over the accuracy or display performance of this WMS layer. Source - https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/

- "Floodplains (Bottomland Hardwoods)" geospatial data were sources from EPA and rasterized to speed display performance. Source - https://edg.epa.gov/data/public/ORD/EnviroAtlas/National/ConterminousUS/; https://enviroatlas.epa.gov/enviroatlas/DataFactSheets/pdf/Supplemental/EstimatedFloodplains.pdf

- The "Hillshade" was derived using USGS DEM data and can be used to help assess surface topography and drainage. Source - https://data.usgs.gov/datacatalog/data/USGS:3a81321b-c153-416f-98b7-cc8e5f0e17c3

- "Percent Slope" was derived using USGS DEM data and can also be used to identify steep slopes where the potential for erosion may be an issue of concern. Source - https://data.usgs.gov/datacatalog/data/USGS:3a81321b-c153-416f-98b7-cc8e5f0e17c3

## F. **TOOLS**

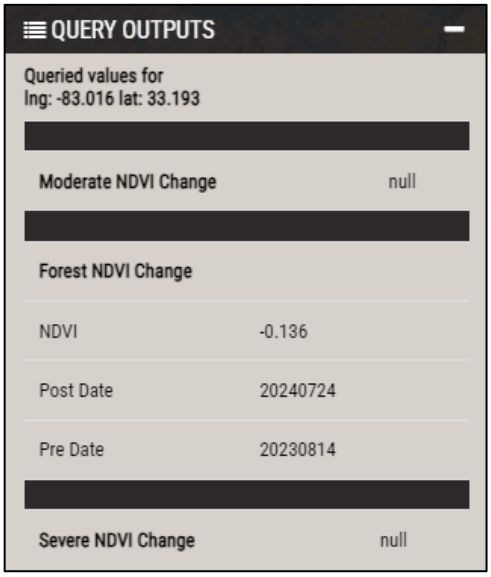



Employing either tool will cause a dialog screen to display that will guide the user in how to use the respective tool.

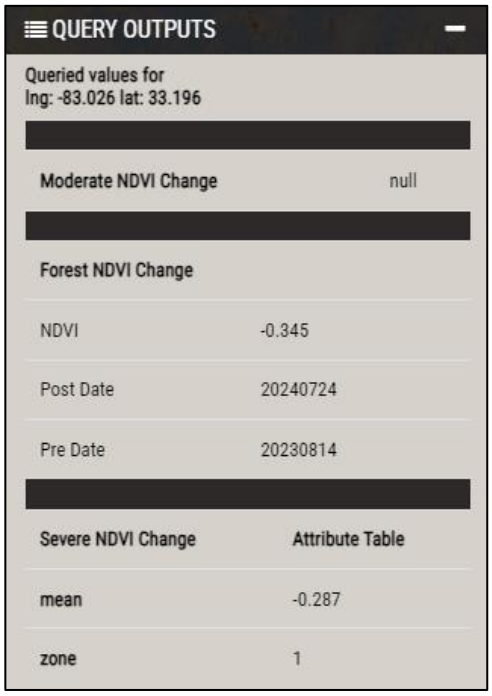
(red arrow) Making active the "**Pixel Tools**" will enable the user to make inquiries of the results displayed on the screen. Double clicking on the analysis results on the map interface will cause layer-related results to be reported to the "**QUERY OUTPUTS**" tab at the lower right portion of the browser window, and above the "**LEGEND**".

**QUERY OUTPUTS**: Double-clicking on the mapped area will return layer results from the selected cursor point of inquiry. Explore querying on different layers. The forest change raster will return (i) the lat-long for the point chosen, the pre- and post-disturbance dates used to calculate NDVI change and the amount of forest NDVI change for that point. Double-clicking on a red or green polygon will report (ii) the lat-long, dates used for the pre and post for that pixel, and the mean forest NDVI change for the respective polygon area (date format = YYYYMMDD).

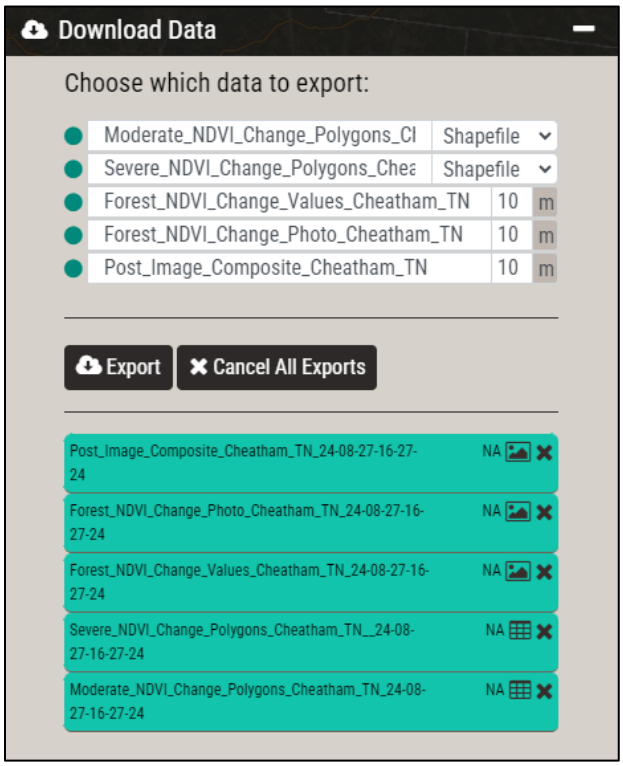
(i)




(ii)




G. **Download Data**



**Moderate NDVI Change Polygons** – Polygon shapefile representing thresholded NDVI change values -0.07 to -0.19 with a patch size greater than or equal to 2 hectares.

**Severe NDVI Change Polygons** – Polygon shapefile representing thresholded NDVI change values greater than or equal to -0.20 and worse decline with a patch size greater than or equal to 1 hectare.

**Forest NDVI Change Values** – a forest-masked 10m raster with 'signed 8-bit' values (-127 to 127) representing absolute NDVI change. This raster product allows further thresholding of digital number values to isolate a user-specified range of forest-only NDVI change values. This single band greyscale raster requires the ***HiForm*** colormap to display in ***HiForm*** colors, see https://drive.google.com/file/d/1NSSmK6MSNM08cbVQU4kNPHow55hlNita/view?usp=sharing

**Moderate NDVI Change Photo** – a 3-band, forest-masked 10m raster with values representing the RGB color combinations for the ***HiForm*** color map applied. The raster product does not require a color map and values should not be edited.

**Post Image Composite** – The post disturbance image used to calculate NDVI change. The 4-band raster contains the appropriate bands needed to render the 10m satellite image as a natural color image (RGB band 1 = red, band 2 = green, and band 3 = blue) or rendered as a false color infrared composite (RGB band 1 = nir, band 2 = red, band 3 = green). See 'Optional' section "D" of this document, page 5-6 for more information on rendering this image.

H. **Support**

In this section you will find links to help documents, acknowledgements and points of contact.

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## A Guide to Interpretation and Assessment

### I. Non-target false positives (remote sensing errors of commission)

i. **Clouds and cloud shadows** – although thin cirrus clouds can reduce NDVI values, and it may not be enough to reach the cloud masking threshold, as a result false positives (not a forest disturbance) polygons may be created. Display the pre and post to visually interpret and confirm the presence of clouds. Make note that polygons adjacent to identified cloud-masked areas may actually be thin cirrus or transparent cloud edge polygons.

ii. **Severe weather: wind, hail, frost, windthrow and leaf strip** – if severe weather is suspected as the cause for creating disturbance polygons, searching for local news reports or viewing NOAA Storm Reports may provide information. To mitigate short-

term, or ephemeral forest disturbance affects, sometimes allowing a short period of time to pass before attempt to re-map may allow more storm related affects to be better resolved. Assessing change to deciduous forest cover during leaf-off can be partially accomplished by viewing the pre and post true color images during that time of year, a more accurate assessment of deciduous change severity would be accomplished by waiting for spring green-up to re-map. Short-term ephemeral deciduous change can similarly be resolved by allowing time for deciduous to re-leaf. In the latter case, severity can be masked by understory compensatory greening.

iii. **Insect / disease** – be aware defoliation from these agents may cause non-target polygons to be created. Display the pre and post disturbance images to help assess the presence. Check local news for reporting of insects and/or disease.

iv. **Development / construction** – NDVI decline in forested areas (defined by 2021 NLCD) will be identified and polygonised. Display the pre and post disturbance images to help assess the presence of development activity.

v. **Prescribed burning and wildfire** – image interpret the pre and post to help assess. Prescribed burning and wildfire leave visual clues as to their occurrence, NDVI recovery in these areas can challenge interpretation.

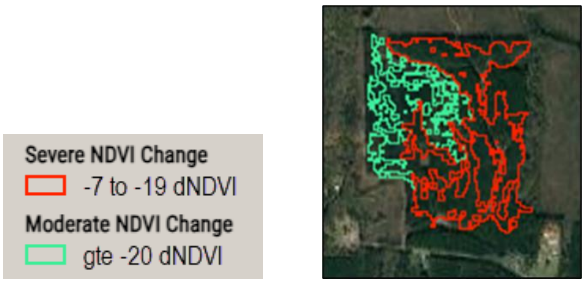
**J. Harvest and length of timeframe being reported (NDVI recovery)**

i. **Starting condition** – it is standard to perform NDVI change analyses using pre and post disturbance dates that are phenologically similar (i.e. growing season anniversary dates, within growing season, winter to winter). The longer the baseline length the more disturbance will be mapped, from all causes. Be aware that performing a 6mo NDVI change analysis from a mid-summer date will place the pre in the middle of winter, thus comparing a summer to a winter date, something we do not encourage, but may provide results.

ii. **Time since harvest** – if an 'adequate' amount of time has passed since first disturbance has taken place, NDVI values may have had time to recover to some degree. More information regarding other spatial indicators of change and their characteristics can be found in this FS Forest Health Monitoring publication, https://research.fs.usda.gov/treesearch/64360 (Norman, Christie, 2022).

**K. The 'Moderate-to-Severe' threshold**

i. **Adjacency of the forest disturbance categories** – the metric used is NDVI change, and we've defined two different NDVI change thresholds denoting two levels of NDVI decline severity. Often both disturbance classes are tightly intermixed which more can likely suggest a condition where there has been slightly recovering NDVI directly adjacent to higher NDVI decline (that was originally more severely disturbed forest and exposed soil).




## L. The 2021 NLCD Forest mask

i. **The definition of 'forest'** - ***HiForm***-BMP relies on using a forest mask to isolate forest-only landcover. The application uses the (4) forest-related classes available in the 2021 NLCD dataset (Deciduous #41, Evergreen #42, Mixed Forest #43 and Woody Wetlands #90). When used after the publication date, there will be subsequent changes in land use and land cover that is no reflected in forest mask used to produced results. Sometimes the aerial photography base map can aid in the assessment of disturbance polygons if related to timber harvest or other silvicultural activity.

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**DISCLAIMER**

This tool is designed to support monitoring and assessment. False positives from non-target disturbances, clouds, cloud shadows, and other atmospheric anomalies can occur. Validation for specific needs is the responsibility of the user.

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***HiForm***-BMP Application - https://apps.fs.usda.gov/lcms-viewer/hiform-bmp.html

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