Hurricane damage to forests can be severe, causing millions of dollars of timber damage and loss. To help mitigate this cost, various approaches require information for the detection and monitoring of forest damage. NASA’s MODerate-resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) time series data products offer a potential resource for mapping hurricane-induced forest damage and recovery across a region. In response, a project was conducted to produce and assess 250 meter forest disturbance and recovery maps in southern Mississippi using the MODIS. The products are currently being implemented at the Mississippi State University for forest inventory (MIFI). A series of NDVI change detection products were computed to assess hurricane induced damage and recovery. Such forest damage maps were derived by computing percent change between MODIS MOD13 16 day composited NDVI per hurricane “baseline” products (2003 and 2004) and post hurricane NDVI products (2005). Recovery products were then computed in which pre-storm (2003, 2004, and 2005) NDVI data was subtracted from post-storm (2005) data with the resulting product then windowed for a 15 day period of August 20 through September 15 for each year in the study. (Table 1). This provided percent change in the measured NDVI for the 3 year period prior to the hurricane event in each of subsequent years through 2008, resulting in forest disturbance products for 2005 and recovery products for the following years.

These disturbance and recovery products were produced for the Mississippi Internet for Forest Inventory (MIFI) Southeast inventory district (Figure 1) and for the entire hurricane impact zone. MIFI forest inventory products were used as ground truth information for the project. Each MODIS percent change product was classified into 6 categories of forest disturbance impacts. Staged age and forest type/cover class products, also provided by MIFI, were used along with the forest disturbance/recovery products to create forest damage stratification products integrating 1) stand type classes, 2) age stage classes, and 3) forest disturbance/erosion classes. This stratification product will be used in MIFI forest inventory planning and to prepare for damage assessments due to future hurricane events. Validation of MODIS percent change products was performed by comparing the MODIS percent change products to those from land data for the same time period and inventory district area.

RESULTS

- The immediate pre-storm change product shows evident regional impacts to forests (Figure 2) with the greatest negative NDVI changes occurring in coastal and bottomland hardwood forests. Seventeen NDVI drops were noted in storm surge impacted forests. As expected, the areas closest to the coast tended to show severe negative NDVI drops than those further from the shoreline. NDVI drops occurred in inland forests when substantial wind was responsible for disturbance to the crowns of trees as well as blow down and sheer damage; these effects are noticeable across the entire MIFI Southeast inventory district.
- Subsequent annual evaluations through 2009 show a gradual recovery in terms of NDVI values. Although the full extent of forest damage and recovery may only be partially measured by NDVI, it does provide a useful measurement for disturbance on the ground.
- The extent of the hurricane disturbance and recovery, as measured by NDVI, is shown in Figure 3. The latter products were computed in which post-storm (2005) NDVI data was subtracted from pre-storm (2003 and 2004) NDVI data. All of the change images represent a map of forest disturbance/damage products. The steps taken in this model were:
  - Compute MODIS NDVI change products. The results shown here are for the 6 classes that were the result of timber cutting in the initial event.
  - Generate forest disturbance/damage products at 250 meter resolution using MIFI’s Forest Type land cover assessment products.
  - Generate forest disturbance/damage products for different 16 day composited window with special focus placed on the August 20 to September 15 composite window (Window 15).
  - The Federal Geographic Data Committee — automatically generated.
- This conclusion is further supported by the fact that the MIFI forest management database showed minimal improvement in unstormed coastal hardwoods in the initial years while other forests close to the coast showed substantial recovery.
- Phosphor plots were computed which show the area of forest types within each of the damage classes for the entire Southeast inventory District and for each of the individual counties within the district over the study period to further assess forest disturbance and recovery. (Figure 4) Validation of the MODIS data products to estimate percent NDVI change was conducted by comparison to products based on similar techniques with higher spatial resolution FIA/MIF products. The results show high correlation and accuracy in the assessment of forest damage.
- The disturbance/damage products were also cross referenced with MIFI raster products indicating forest stand type, age, and forest age. (Table 2) These analysis indicates which types of trees were most heavily impacted by the hurricane event, useful information for timber managers to understand. Figure 5 is a map of forest types versus forest age.

CONCLUSIONS

Validation efforts support the technique of using MODIS-based NDVI percent change products to quantify the effect of Hurricane Katrina on coastal forests. Furthermore, this technique is extendable to evaluations of other natural events to forest ecosystems such as wildfires. In this study, the spatial resolution of MODIS may be too coarse for some applications, the reported approach can be used to extract more spatially directed timber inventories with ground sampling. Since ground sampling timber inventory activities can be costly, this MODIS-based approach can significantly reduce costs by reducing man power and labor.

REFERENCES


Table 2: Comparison of the shape characteristics and NDVI damage classes for all evergreen trees in the Southeast inventory district.